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NINTH ANNUAL REPORT
of
Pasture Research
in the
Northeastern United States
State College, Pennsylvania
1945



1945

Ninth Annual Report
of
Pasture Research
in the
Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania

Division of Forage Crops and Diseases
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were made and distributed as follows:

Seven copies to the Division of Forage Crops and Diseases; one copy to each of the twelve Directors of the cooperating State Agricultural Experiment Stations in the Northeastern United States; one copy to the President of The Pennsylvania State College; one copy to the Conservator of the Northeastern Region of the Soil Conservation Service, Upper Darby, Pennsylvania; one copy to the Director of each of the following State Agricultural Experiment Stations--Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Virginia, and Wisconsin; one copy to the Dominion Agrostologist, Ottawa, Canada; one copy to the Main Library of the Department of Agriculture, Ottawa, Canada; one copy to the Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; one copy to the Director of the Swedish Seed Growers Association, Svalöf, Sweden; one copy to the Director of the Waite Agricultural Research Institute, Adelaide, Australia; one copy to the Librarian, Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, A.C.T., Australia; and the remaining copies to the U. S. Regional Pasture Research Laboratory.

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* * * * *

* This annual report of activity at the Pasture *
* Laboratory, as well as of that at the state *
* stations with which the Laboratory cooperates, *
* is a progress report and as such may contain *
* statements which may or may not be verified *
* by subsequent experiments. The fact that any *
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* the state station concerned. *

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REPORT
of the
UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY
for the Calendar Year 1945

INTRODUCTION

The year 1945 will go down in history as momentous both because of the end of World War II and of the dramatic manner of its ending. The dislocations produced by the war still remain and years of patient effort will be required to restore a stable peacetime economy. To bring this about agriculture will play a major role. The demand for agricultural products particularly dairy products continues at peak levels. The Northeastern dairy farmer has every reason to expect that his well kept grasslands will continue to yield satisfactory incomes. Regardless of the economic prospects for the immediate or distant future, however, it is almost self-evident that the grass-legume crops will continue to be the keystone in the agricultural arch for most farm land in the Northeastern States.

During the war agricultural effort including research was motivated primarily by the need of increased production, more or less regardless of cost. We were inclined to take a short-term view of things and were working under pressure to bring about greater and greater production. Now that the war is over we can be somewhat more circumspect and again take up the study of problems from the standpoint of the long-term requirements of the region. We still need greater production but with emphasis on efficiency and quality and certainly not at the cost of sacrificing our most valuable natural resource, the soil.

Agricultural research at the Laboratory, particularly the field work, during the year was handicapped somewhat by a shortage of routine help. It was necessary for the project leaders to spend considerable time in the routine of harvesting and determining yields of experimental plots, time that under more normal circumstances might have been better spent in the more technical studies of plant material and growth responses. Nevertheless by performing only the more essential field tasks and with the help of high school boys in addition to the few regular employees, it was possible to get through the summer without serious loss of experimental data.

The Pasture Collaborators did not hold a meeting in 1945. The only meeting of regional significance held at the Laboratory was a conference suggested by Doctor E. A. Hollowell of the Division of Forage Crops and Diseases to consider the maintenance and purification of Ladino clover seed stocks. Plans were developed for testing Ladino clones in the Northeastern States and elsewhere for adaptability and purity of type with the aim of having the more desirable clones serve as foundation material for seed production. A mimeographed report of the conference was mailed to each Collaborator.

It is with regret that we record the death of one of our Collaborators, the late Doctor B. E. Gilbert of the Rhode Island Station.

The organization of the present report is similar to that of the earlier reports.

COOPERATIVE RESEARCH BETWEEN STATE STATIONS
AND THE LABORATORY

FOUNDATION SEED STOCKS OF LADINO CLOVER

At the conference on purification and maintenance of Ladino clover seed stocks (page 2 of this report), it was agreed that an important solution of the present problem of contamination of Ladino with seed of ordinary white clover would be to provide a new source of foundation seed that could be maintained in the future by clonal propagation and seed production under certification. For this purpose, selected clones were available, including 55 from the Laboratory and a few from New Hampshire and New Jersey. These clones were included, along with clones from other stations outside of the Northeastern Region, in a uniform testing program to evaluate their adaptability throughout the country. The clones that prove superior and that prove, from progeny tests, to be free of contamination with white clover will be used as a new source of foundation seed of Ladino clover.

AGROSTIS TENUIS BREEDING
(WITH RHODE ISLAND)

Title: Breeding Rhode Island Colonial Bentgrass for Pasture Types.

Leaders: For the Rhode Island Agricultural Experiment Station - Irene H. Stuckey.
For the Pasture Research Laboratory - W. M. Myers.

Since susceptibility to disease and low yields appeared to be the most serious weaknesses of commercial Colonial bentgrass, selections and notes made from clones and from single-spaced plants emphasized both these qualities.

During the summer of 1944 seed was collected from 134 leafy disease resistant single spaced plants. In February the seed was sown in the greenhouse and in April forty plants of each progeny were set in the field. Some of these progenies appear to be promising sources of material for developing disease resistant strains of Colonial bentgrass.

The chromosome counting of divergent morphological types was continued with results that confirmed the previous findings.

At the time this project was begun good bluegrass-white clover pastures were considered to be ideal for most of the Northeast but in coastal New England, Colonial bentgrass appeared superior to Kentucky bluegrass. Hence, it seemed advisable to try to develop improved strains of this bentgrass. In more recent years, however, tall grass-legume mixtures have proved more satisfactory than the best bluegrass-white clover pasture under most conditions and it is now felt that improved strains of the grasses which are inherently higher yielding than Colonial bentgrass, perhaps orchard grass, smooth brome grass or timothy, will be better pasture grasses than can possibly be developed from bentgrass.

Bentgrass, however, is very satisfactory for lawns and fairways and at present interest is increasing rather than decreasing in the use of this grass for this purpose.

Notes made during 1943-45 indicate that the fine leaved types of Colonial bentgrass are more resistant to both leaf spot and rust than the taller pasture types of grass (especially to the Helminthosporium leaf spot). Thus, while no practical application can be made of this work to pasture problems, the work already done will not be lost since it can be applied directly to fine turf work. The chromosome studies add to our fundamental knowledge of grasses. The condition found here with the bentgrasses has not previously been reported as occurring in any other species of grass.

DACTYLIS GLOMERATA BREEDING
(WITH MARYLAND

and

DIVISION OF FORAGE CROPS AND DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass (Dactylis glomerata) Strains Adapted Particularly for Pastures in Maryland.

Leaders: For the Maryland Agricultural Experiment Station
- W. B. Kemp.
For the Division of Forage Crops and Diseases -
M. A. Hein and R. E. Wagner.
For the Pasture Research Laboratory - V. M. Myers.

Collection of Material. A space-planted nursery of about 5500 plants was established at State College, Pennsylvania, to serve as a source of material for further selection. The seed for these plants came from six collections made at the

Soil Conservation Service Nursery, Big Flats, New York, one collection from a 50-year old stand of orchard grass in Central Pennsylvania, 10 introduced varieties, and 33 strains produced in this breeding program.

Selection Nursery. Korean lespedeza was seeded in the breeding and selection nursery established at Beltsville in the fall of 1944 to serve as a companion crop and to help control weeds. This nursery, consisting of 33 strains of orchard grass, should provide abundant material for selection in 1946.

Selection and Evaluation of Plants. One hundred twenty-eight new selections were made in the summer of 1945, increased vegetatively in the fall of 1945, and planted in 15 replications in a polycross plot at State College. Another polycross plot with 15 replications was established with 173 clones that had been selected as superior from the two previous polycross plots (1942 Annual Report, page 7, 1943 Annual Report, page 5).

From among the 315 clones in the 1943 polycross plot (1943 Annual Report, page 5), 63 clones were selected as superior on the basis of their behavior as replicated spaced plants in the polycross plot and seed was harvested from these clones.

Sufficient seed for replicated plot tests was obtained from 102 clones from the 1942 polycross plot. These were seeded in plots with Ladino clover in the spring of 1945 at State College, Pennsylvania, and were mowed periodically in 1945 to suppress weed growth.

Strain Trials. In addition to the studies of interaction of varieties, management, and associated legumes (page 38 of this report), 16 varieties were seeded with Ladino clover in four replications at State College, Pennsylvania. The varieties included Commercial, Tammisto, Finnish Late Hay, C-23, and 12 new varieties produced in this breeding program.

Strain Trials at the Agricultural Research Center. In the fall of 1944, 16 strains of orchard grass were seeded in mixtures with red and Ladino clover in a dairy pasture at the Beltsville Agricultural Research Center to determine their performance under actual grazing conditions. The different strains consisted of Tammisto, Finnish Late Hay, Brage, S-26, S-143, the Maryland hay and pasture selections and nine new strains from isolation blocks grown at Beltsville and the Pasture Research Laboratory.

Observational notes were made throughout the summer and plant population counts were taken on all plots in the fall of 1945. The stands of the Maryland hay and pasture strains as

determined by the plant counts were outstanding, while Isolation Plot 6 and Finish Late Hay stands were the poorest of the group. Others were rather uniformly intermediate.

Seed was harvested from 15 of the 21 isolation plots at State College, Pennsylvania.

Isolation Blocks. Seed was harvested from the five isolation blocks in 1945. There was considerable variation among plants in vegetative and seed-producing characteristics and in many cases in dates of heading and maturity within all blocks with the possible exception of XIV-XV. This block showed much more uniformity than any of the others, although the plants varied considerably in amount of seed production. In view of the extreme variability in these blocks, consideration should be given to replacing them with similar isolation blocks of more promising and more uniform material when such is available.

Further Selection and Increase of Maryland Strains. The performance of the Maryland hay and pasture strains of orchard grass has been such in tests at Beltsville, Maryland, and at the Pasture Research Laboratory that it was felt advisable to increase the source of seed of these strains for further testing and eventual distribution. As a move in this direction, 1275 plants of the pasture strain and 1304 of the hay strain, or a total of 2579 plants were established in a space-planted nursery in the fall of 1945. Of the 1275 plants in the pasture strain, 495 were established from seed and 780 were taken from the old Uniform Grass Nursery. Likewise, 496 plants of the hay strain were established from seed and 808 taken from the old nursery. This planting will serve as a source of material for further selection as well as for increase of the seed supply.

MEDICAGO SATIVA BREEDING

(WITH NEW YORK AND
DIVISION OF FORAGE CROPS AND DISEASES)

Title: Breeding Improved Alfalfa for the Eastern United States.

Leaders: For the Cornell University Agricultural Experiment Station - S. S. Atwood.
For the Division of Forage Crops and Diseases - H. M. Tysdal.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

(WITH NEW JERSEY AND
DIVISION OF FORAGE CROPS AND DISEASES)

Title: Breeding and Testing Alfalfa for Pasture and Forage.

Leaders: For the New Jersey Agricultural Experiment Station - G. H. Ahlgren.
For the Division of Forage Crops and Diseases - H. M. Tysdal.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

These two cooperative projects represent research phases in the Northeastern Region of the eastern alfalfa improvement program that is coordinated through the Eastern Alfalfa Improvement Group. Two meetings of the group were held in 1945, the first at Beltsville, Maryland, and the second at Columbus, Ohio. At these meetings, progress reports were given and plans were made for further exchange of materials among the cooperating agencies. Minutes of these meetings were mimeographed and distributed to those in attendance.

In the two cooperative projects reported here, research results and materials produced in the phases of the program for which the Laboratory has responsibility will be available equally to the other cooperating agencies. For sake of continuity and to avoid repetition, the progress reports from the two projects are presented as a unit except that details of the breeding work conducted at Ithaca, New York, are presented in the New York State Report of cytogenetics and breeding at the Cornell Agricultural Experiment Station.

Source Nurseries. Space-planted nurseries to serve as sources of material for selection have been established at Ithaca, New Brunswick, and State College. At New Brunswick, the planting consisted primarily of old plants collected from many sections of New Jersey. At State College, a source nursery of approximately 4600 plants was established in the spring of 1945. These consisted of 540 clones of plants collected from old fields in Pennsylvania, 23 clones selected from Atlantic (by G. H. Ahlgren and H. M. Tysdal), and plants from seed of 14 collections in Pennsylvania and 79 varieties, strains, single crosses, poly-crosses, etc. obtained primarily from the midwestern alfalfa breeding programs.

Evaluation of Clones of Individual Plants. A total of 31 clones from old fields in New Jersey was increased vegetatively by cuttings, inoculated with wilt (cultures obtained from Doctor F. R. Jones by Professor Haenseler), and transplanted to the field at New Brunswick in four replications of clonal rows, 5 plants per row. During the summer of 1945, differences among these clones in vigor, leafiness, and resistance to yellowing were noted. Some wilt symptoms were evident, indicating that the inoculation had been successful.

Similarly, 112 clones were increased vegetatively and planted in the field in 4 replicated, 5 plant, rows at State College. These clones consisted of 24 received from Mr. Crandall, 23 selected from Atlantic, and 65 selected as creeping types from old fields in Pennsylvania.

During the summer of 1945, striking differences were noted among plants in the source nursery at State College in freedom from leaf hopper yellowing and in resistance to Pseudopeziza leaf spot. Approximately 175 plants were selected as superior in these two characters, increased vegetatively by cuttings in the fall, and inoculated with wilt in the greenhouse. The clones that prove resistant to wilt will be planted in replicated rows in the field in the spring of 1946.

Hybridization to Obtain Recombination of Characters. Because of the importance of wilt resistance and the expected desirability of a strongly rhizomatous habit such as is exhibited by the "Oregon creeper" clones, a hybridization program, designed to combine these characters, was started. Three wilt resistant clones that have given promising results in the breeding program at Lincoln, Nebraska, were crossed in the greenhouse at State College

with three "Oregon creeper" clones and three clones from F.P.I. 117,014 (goat pasture clones). Seed was obtained from 15 crosses and the F_1 plants were planted in the nursery in the spring of 1945. Three to four F_1 plants from each cross were selected on the basis of vegetative vigor, resistance to Pseudopeziza leaf spot, leafiness, growth habit, and other characters. These are being sib mated in the greenhouse to produce seed for the F_2 generation.

POA PRATENSIS BREEDING (WITH PENNSYLVANIA)

Title: Breeding Kentucky Bluegrass for Improved Pasture Types.

Leaders: For the Pennsylvania Agricultural Experiment Station -
H. B. Musser and S. I. Bechdel.
For the Pasture Research Laboratory - W. M. Myers.

Progeny Uniformity Tests. Records on uniformity and general desirability were taken on the progenies of 133 selected plants. These progeny tests were planted in the fall of 1943. On the basis of these records, 111 progenies were discarded and seed was harvested from the remaining 22. This seed will be used for preliminary plot trials as soon as facilities can be arranged.

Seed Increase. Seed was harvested again from the four improved strains of Kentucky bluegrass (1943 Annual Report, page 16). The half-acre increase plots of two strains (1944 Annual Report, page 7) were mowed periodically during the summer to suppress weed growth. It is expected that seed can be harvested from these areas in 1946. Seed was harvested from small seed increase plots of 14 strains (1942 Annual Report, page 9) that are being used in various strain trials at the Laboratory (page 39 of this report).

Advanced Strain Trials. The replicated pasture plots seeded in the spring of 1944 (1944 Annual Report, page 7) were grazed periodically with dairy cows during the summer of 1945. The most important result obtained was demonstration of the fallacy of this type of experimental setup. The plots were seeded in a single pasture so that cows were permitted to graze all plots without restriction. As a result, the plots of strains known from clipping tests to be low yielding were grazed almost exclusively. Plots of the more vigorous, higher yielding strains were almost untouched.

POA PRATENSIS AND TRIFOLIUM REPENS BREEDING
(WITH WEST VIRGINIA)

Title: Breeding and Improvement of Pasture Grasses and Legumes.

Leaders: For the West Virginia Agricultural Experiment Station - Collins Veatch and J. G. Leach.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At Morgantown, West Virginia

Seed was saved again this year from the forty lines which showed the least number of off-type plants. Notes were taken on the planting of these strains, mentioned in the 1944 Annual Report, page 8, and thirteen of the most vigorous growing strains are being tested for smut resistance. Seeds from the strains which prove smut resistant will be planted in increase plots and yields will be taken on the plots planted last year.

Further studies were made of bluegrass smut, Ustilago striaeformis, in culture. Chlamydospores are formed on agar in great abundance and, although some of them are slightly abnormal in size and shape, they germinate normally, producing cultures indistinguishable from those arising from spores produced on bluegrass.

Spores germinate by forming one or more branched germ tubes that grow into a mycelium on nutrient agar. Two types of colonies occur: one that breaks up into short fragments, and one that is typically mycelial in character. Both types of growth may produce spores, but certain cultures of each growth type have not sporulated.

Conventional methods of seed inoculation resulted in low percentages of infection. Relatively good infection was obtained by soil inoculation and by injecting spores with a hypodermic needle into the stem near the growing point.

Infection from the soil is not confined to the young coleoptile, but may occur on older plants, probably through young tillers.

The practicability of inoculating vegetatively propagated clones of bluegrass has been demonstrated and the importance of the method in a program of selecting or breeding smut-resistant strains of bluegrass is pointed out.

One selection, No. 528, has been tested and found to be highly resistant to smut. It is being propagated for further test and small pieces of sod have been planted in a heavily smut-infested pasture for trial under field conditions.

A cytological study of the smut as it grows in culture is being made. The results of the study will be reported later.

At State College, Pennsylvania

Physiology of Afterripening in Chlamydospores. Moisture and high temperature were found necessary to stimulate germination of fresh smut chlamydospores from Poa pratensis (1944 Annual Report, pages 54 and 55). During the year several chemicals were tested to determine their effectiveness in breaking dormancy of the spores. Earlier reports in the literature listed benzaldehyde as hastening germination of chlamydospores of Urocystis tritici. A concentration of three parts benzaldehyde in 2,000,000 parts of water was recommended.

In order first to determine whether or not this chemical was injurious to the stripe smut spores, a quantity of the chlamydospores were afterripened by the method developed at the Pasture Laboratory and then placed in dilutions of benzaldehyde ranging from 1:500 to 1:3,000,000. No injury to germination resulted in any of the dilutions even in the 1:500 concentration. Fresh, non-afterripened spores were placed in a similar series of benzaldehyde dilutions and left overnight. None of the spores in any concentration of benzaldehyde germinated nor did the controls, thus suggesting that benzaldehyde was not effective in breaking dormancy of spores of Ustilago striaeformis.

In another experiment fresh, non-afterripened spores were incubated at 35° C. in contact with different concentrations of benzaldehyde ranging from a saturated aqueous solution to a 1:1000 dilution. There was some slight indication that spores incubated at 35° C. in the 1:1000 solution of benzaldehyde afterripened sooner than those incubated in water but the total germination secured from spores afterripened in benzaldehyde was no greater than from spores afterripened in water. Furthermore, the spores afterripened in most dilutions of benzaldehyde reached maximum germinability about the same time as the spores afterripened in water thus offering no advantage in using the chemical.

Afterripened and non-afterripened smut spores were treated in di-ethyl ether for different lengths of time from a few seconds to four hours. This was done to dissolve any fatty

substances that might coat the spore wall, thus making it impervious to water. Treatments for as long as four hours failed to injure germination of afterripened smut spores but also failed to break the dormancy of non-afterripened spores.

It was also shown that germination of afterripened smut spores was not lowered by treating them 30 minutes in absolute ethyl alcohol. However, all dilutions of ethyl alcohol to a lower limit of 10 percent injured germination. Afterripened spores could be treated as long as 60 minutes in absolute alcohol before injury to germination resulted. Treatment with absolute alcohol had no effect on germination of non-afterripened smut spores.

Since thiourea and allyl thiourea have been shown to break dormancy of some seeds, dilutions of these compounds were tested on afterripened and non-afterripened smut spores. Concentrations of thiourea greater than 0.25 percent were injurious to afterripened spores. All concentrations including the most dilute (0.125 percent) of allyl thiourea were injurious to germination of afterripened spores. None of the concentrations of either chemical induced germination of non-afterripened chlamydospores.

To date, no chemical treatment has been found equal to incubation at 35° C. in a moist chamber for afterripening chlamydospores of Ustilago striaeformis. Experiments are still in progress to discover a chemical treatment that will simplify the afterripening process and perhaps give a clue to the nature of dormancy in the spores.

Response of Chlamydospores from Different Grasses to Afterripening. Since earlier work conducted at the Laboratory (1943 Annual Report, page 57) suggested that chlamydospores from several grasses responded differently to afterripening, new collections of smutted orchard grass, timothy, bentgrass and Kentucky bluegrass were made and transplanted to the greenhouse. At periodic intervals, spores from each host were given the temperature afterripening treatment and tested for germination. In general, the earlier work was substantiated since chlamydospores from Kentucky bluegrass and bentgrass responded readily to the afterripening treatment while chlamydospores from timothy and orchard grass responded less readily. The maximum germination secured with afterripened chlamydospores from Kentucky bluegrass and bentgrass was 75 to 90 percent. Timothy occasionally responded well to the afterripening treatment and germinated 75 percent, but the response usually was slower and total

germination was less. Chlamydospores from orchard grass seldom responded to the afterripening treatment with germination greater than 25 percent. These results may indicate fundamental strain differences.

TRIFOLIUM REPENS BREEDING (WITH NEW JERSEY)

Title: Breeding White Clover for Pastures.

Leaders: For the New Jersey Agricultural Experiment Station -
G. H. Ahlgren.

For the Pasture Research Laboratory - W. M. Myers.

Progeny Test of Diallel Crossing System. Parent plants 6-3, 6-5, 6-6, 6-9, 6-10, 6-15, and 6-16 have been judged superior in their combining ability as determined by the progeny test. These seven plants were selected from a group of twenty after four years of testing.

The past season has been devoted to increasing clonal material from each of these plants. Three isolated areas were selected and clones for three crosses from the above group of plants were set into the field. No seed was harvested this past season.

Open-pollinated Breeding System. Approximately 1-1/2 pounds of clover seed were collected from an isolated plot growing the superior plants left from this breeding system. These plants remained after a vigorous weeding and eliminating of inferior-appearing individuals from several plantings over a period of four years.

TRIFOLIUM REPENS, TRIFOLIUM PRATENSE AND PHLEUM PRATENSE BREEDING (WITH NEW HAMPSHIRE)

Title: The Improvement of Ladino Clover, Red Clover and Timothy by Selection and Breeding.

Leaders: For the New Hampshire Agricultural Experiment Station -
Ford S. Prince, L. J. Higgins, P. T. Blood.

For the Pasture Research Laboratory - W. M. Myers.

Ladino clover.

1. At Durham, New Hampshire, testing of 24 plants representing parent material continued during 1945. All of these were propagated clonally in a new orchard grass seeding in 1944. Their behavior varied greatly, so much in fact that many new ones

will be selected for use in developing a strain rather than those originally chosen. These will be caged in 1946. Due to inability to purchase screen wire, no caging was done in 1945. This condition has been remedied for 1946.

Twenty seedlings from each of seven parents grown under a cage in 1944 were produced in 1945 in rows with Ladino for comparison. On the basis of observation and scoring, six of the seven were distinctly superior to Ladino, even though, as pointed out, these do not necessarily represent the best material from the breeding program.

Seventy-four plants of white clover and 90 of Ladino clover were grown in spaced rows from seed received from the Pasture Laboratory in April 1944. While these plants exhibited some variation, they represent very desirable material on the whole. Some of these have been brought into the greenhouse this winter for intercrossing with a few of the more desirable New Hampshire Ladino families.

2. At State College, Pennsylvania, the open-pollinated seed from replicated clonal plots of Ladino clover (1944 Annual Report, page 33) was used for seeding replicated plots in association with orchard grass in the spring of 1945. A total of 47 polycross progenies of clones was planted in these tests, including the 15 used in the methods of evaluation study (page 37 of this report). Clones of the 267 plants selected in the summer of 1944 (1944 Annual Report, page 33) were planted in the spring of 1945 in a polycrossing block of ten replications. Five of the replications were cultivated as spaced plants while on five replications a uniform seeding of orchard grass was made immediately following transplanting of the clover clones. The latter replications were mowed periodically during 1945.

Red Clover. Over two dozen vigorous red clover plants have been potted and placed in the greenhouse for hand intercrossing. These plants are descendants of the 12 original families that lived and produced seed for four and five seasons. Weak plants and those that show susceptibility to disease are being discarded.

Comparative trials with perennial red clovers from other sources are already under way. During the past season about two bushels of seed of the New Hampshire perennial strain were produced. This will be distributed to other stations and used for comparative farm tests over the state.

Timothy. Testing of two strains of timothy is now proceeding on a field scale in various locations in New Hampshire. These include a late hay strain and a shorter strawed, but very leafy strain designed for pasture. Seed of both strains has been multiplied so that enough is available for farm as well as comparative experiment station testing.

MICRO-CLIMATE STUDIES (WITH VERMONT)

Title: Micro-climate and the Growth of Several Pasture Species.

Leaders: For the Vermont Agricultural Experiment Station -
J. V. Marvin.
For the Pasture Research Laboratory - V. G. Sprague.

Micro-climate Data. A continuous record of several environmental factors has been kept for three years. These factors are air temperature at six feet and at three inches, soil temperature at soil surface and three inches below the surface, relative humidity, precipitation, light intensity, and soil moisture at three, nine, and eighteen inches. These are being continued and results are similar to those reported in the 1944 Annual Report, pages 11 to 13.

Species Tests. One hundred plots of legume-grass mixtures were seeded in 1943. The plots received an application of lime and 400 pounds per acre of an 8-16-16 fertilizer before seeding. They were given a second treatment of one-half ton of lime and 400 pounds of an 0-16-16 fertilizer per acre basis in the fall of 1944.

The plots were cut three times in 1944 (1944 Annual Report, page 13). The Ladino-grass combinations outyielded the other clover-grass mixtures in the following order: Ladino, alfalfa, red clover, and birdsfoot trefoil. The sweet clover plants did not survive the first winter. Reed canary outyielded the other grasses, followed by orchard, brome, and timothy.

In 1945, the plots were cut only twice. Yields from the second cut were very low, because during five weeks in July and August there was little or no rain. Yields for 1945 are given in Table No. 1.

In comparing the data for the two years, it is evident that alfalfa did not yield as well as in 1944. Red clover gave about the same yields, and the Ladino and birdsfoot trefoil yields were slightly higher. Although the summer was unusually dry, the combinations with reed canary grass outyielded those with brome, orchard, or timothy. Timothy again gave the poorest yields.

The botanical composition of the vegetation changed considerably from 1944. to 1945. The percent of alfalfa, red clover, and Ladino clover markedly decreased in 1945, but birdsfoot trefoil remained about the same.

Table 1. Total yields in pounds per acre of the several grass-legume mixtures in 1945.

	: Reed :	:	:	:	:	:
	:canary:	Brome-	Orchard:	Timo-	No :	Aver-
	:grass :	:grass :	: grass :	thy :	:grass :	: age
Ladino clover	: 3774 :	: 3893 :	: 3063 :	: 3629 :	: 2154 :	: 3303
Alfalfa	: 3990 :	: 3286 :	: 3256 :	: 2874 :	: 2576 :	: 3196
Red clover	: 3608 :	: 2685 :	: 3740 :	: 2803 :	: 2672 :	: 3102
Birdsfoot Trefoil	: 2966 :	: 2891 :	: 2838 :	: 3123 :	: 2940 :	: 2952
Sweet clover	: 2105 :	: 2993 :	: 2581 :	: 2257 :	: 2491 :	: 2485
Average	: 3289 :	: 3150 :	: 3096 :	: 2937 :	: 2567 :	:
	: :	: :	: :	: :	: :	:

ENVIRONMENTAL STUDIES WITH COLONIAL BENTGRASS (WITH RHODE ISLAND)

Title: Studies of the Behavior of Agrostis tenuis
(Colonial Bentgrass) as Influenced by Environmental Factors.

Leaders: For the Rhode Island Agricultural Experiment
Station - Irene H. Stuckey.
For the Pasture Research Laboratory - Vance G.
Sprague.

In order to test the response of Colonial bentgrass to different temperatures, replicated pots of clones and seedlings were grown for eight weeks in the control chambers at the Pasture Laboratory. The temperatures used were 60° F., 55° F., 50° F., and 45° F.; the photoperiod, 14 hours at a uniform light intensity. Definite conclusions cannot be reached from a single run in the chambers but in general the differences between temperature treatments were greater than any differences between genetic lines of plants. Plants grown at 55° F. were consistently better than those grown at 60° F. In some lines a definite break in growth occurred between 55° F. and 50° F.; in some the break was between 50° F. and 45° F.; and in the remainder the change from one temperature to the next was gradual throughout. On the whole, the seedlings showed less difference between lines than clones.

NUTRITION STUDIES (WITH PENNSYLVANIA)

Title: Measurement of the Nutritive Value of Pastures and of Pasture Plants.

Leaders: For the Pennsylvania Agricultural Experiment Station -
E. B. Forbes and J. K. Thornton.
For the Pasture Research Laboratory - J. T. Sullivan
and V. G. Sprague.

Emphasis during the summer of 1945 was placed on the control of weeds and in establishing full stands of plants of each of the grasses and legumes seeded in August 1944. An application of ammonium nitrate at the rate of 125 pounds per acre was made on the grass plots in the fall of 1945, and the same amount will be applied in the spring of 1946.

OVER-LIMING INJURY (WITH CONNECTICUT)

Title: A Study of the Causes of Over-liming Injury to Pasture Species.

Leaders: For the Storrs (Connecticut) Agricultural Experiment Station - B. A. Brown.
For the Pasture Research Laboratory - R. R. Robinson
and V. G. Sprague.

The old pot cultures of alfalfa were discontinued and no new ones started in 1945. The heavily-limed plots, seeded to alfalfa in 1941, were continued the past season.

Results. Although neither the hydrated lime at two tons nor the carbonate of lime at three tons per acre had brought the pH of the soil to 7.0, very marked boron deficiency occurred again in 1945 on all plots where no borax was applied before seeding in 1941. This deficiency has retarded the growth and reduced the stand of the alfalfa enough to permit a much greater spread of grasses. It appears that this is a case of insufficient available boron rather than "over-liming injury", which was not prevented by adding carriers of boron to heavily limed pot cultures of the same soil.

PASTURE MANAGEMENT EXPERIMENTS
(WITH MAINE)

Title: Management Practices as They Affect the
Productivity of Ladino Clover-Grass
Association.

Leaders: For the Maine Agricultural Experiment Station -
C. H. Moran, J. A. Chucka, and G. M. Cairns.
For the Pasture Research Laboratory - V. G.
Sprague.

The objective of this study is to investigate the effects
of several management systems on the seasonal productivity
of Ladino clover-grass mixtures and to determine the effect
of these practices on the maintenance of the legume in the
association.

Duplicate areas were seeded September 2 to 8 to associations
of

1. Bromegrass-Ladino clover.
2. Timothy-Ladino clover.
3. Orchard grass-Ladino clover.

Adverse weather conditions and labor difficulties prevented
a desired earlier seeding.

The three management systems as listed in the 1944 Annual
Report, page 15, will be used on association beginning
with the 1946 grazing season.

PASTURE MANAGEMENT EXPERIMENTS
(WITH PENNSYLVANIA)

Title: Evaluation of Grasses and Legumes for Hay, Grass
Silage, and Pasture for Dairy Cattle.

Leaders: For the Pennsylvania Agricultural Experiment
Station - S. I. Bechdel, P. S. Williams, A. L.
Haskins, and J. K. Thornton.
For the Pasture Research Laboratory - V. G.
Sprague.

Systems of Grazing Management on Orchard Grass-Ladino
Clover. Grazing management trials were begun in 1945 on
the 10-acre field of orchard grass-Ladino clover estab-
lished the previous year (1944 Annual Report, pages 16

and 17). Cattle were first turned out on April 12 on the paddocks receiving early spring grazing. Throughout the summer, the paddock was grazed according to the herbage present and the designated grazing scheme for that paddock irrespective of the condition of the other replicates of the same treatment. In this way a true measure of the variation between replicates could be obtained. Four samples of herbage were harvested from each paddock at the time the cattle were turned in and again at the time the cattle were taken out. In this way the amount of herbage available for consumption was determined and four botanical separations of the herbage, the amount of orchard grass and Ladino clover in the association, were obtained. Records were kept of the total milk yields and grazing days on each paddock. A summary of the first year's results are presented in Table 2.

Table 2. Milk production and grazing days of orchard grass-Ladino clover under several grazing management systems.

Orchard grass-Ladino clover managements	First crop			
	harvested herbage			
	Pounds	Silage	Cow	4% milk
	per acre	tons per acre	days per acre	pounds per acre
Early grazing	-	-	260	9,837
Deferred grazing	-	-	298	10,855
Early grazing + hay + aftermath grazing	1,542	-	144	4,941
Silage and aftermath grazing	1,565	2.61	175	6,727
Continuous grazing	-	-	230	10,008
Kentucky bluegrass	-	-	254	8,489

The grazing data from the several management treatments cannot be accurately compared until the conversion is made to total digestible nutrients. Furthermore, these data represent only the first year's results from a new and well established pasture, and it is quite possible that subsequent data will be different. Of importance equal to that of milk yield or TDN is the maintenance of the stand of grasses and legumes in the sward. Under the system of continuous grazing, plants of wild white clover and Kentucky bluegrass are already becoming more apparent.

Evaluation of Several Grass-Legume Mixtures for Grass Silage and Aftermath Grazing. The first crop of the several grass-legume associations established in 1944 (1944 Annual Report, page 17) was harvested for silage in 1945 and the aftermath grazed. The yields of silage, the milk yields and the pasture days are given in Table 3. It is evident that the orchard grass-Ladino clover association produced the least silage but provided the largest amount of midsummer grazing. Bromegrass-alfalfa produced the largest amount of silage but the least grazing. The timothy-red clover-Ladino association produced a considerable amount of silage as well as aftermath grazing but whether this will be maintained in 1946 after the red clover has disappeared is questionable. At each cutting and grazing date, samples of the herbage were taken for botanical analysis so that the persistence of the several species in each association can be followed from year to year.

Table 3. Yields of herbage and milk production on grass-legume associations used for silage and aftermath grazing.

Grass-legume associations	First crop			
	harvested herbage			
	Pounds	Silage	Cow	4% milk
	per acre	tons per	days	pounds
	of dry	acre of 30%	per	per
	matter	dry matter	acre	acre
Ladino-bromegrass	3,632	6.05	182	6,526
Ladino-orchard grass	2,809	4.68	245	9,645
Alfalfa-bromegrass	5,093	8.49	112	3,388
Alfalfa-orchard grass	3,394	5.66	-*	-*
Red clover, Ladino, timothy	3,719	6.19	200	7,534

* Cows were not available so heifers were substituted for the grazing animals.

PASTURE MANAGEMENT EXPERIMENTS
(WITH PENNSYLVANIA)

Title: Evaluation of Grasses and Legumes for Use as Poultry Pastures.

Leaders: For the Pennsylvania Agricultural Experiment Station
- P. H. Margolf, E. V. Callenbach, J. K. Thornton,
and H. V. Higbee.
For the Pasture Research Laboratory - V. G. Sprague.

Experiment 1. Evaluation of an orchard grass-Ladino association for turkey pastures under two systems of grazing management, differing in intensity.

An excellent stand of Ladino clover and of orchard grass was established in the first grazing season. It was necessary to cut the forage on all plots twice, April 23 and May 15, due to the exceptional early growth of orchard grass, before the turkey poults were large enough to start grazing. Each 2-acre grazing area was divided into four half-acre plots. The more heavily grazed area carried 75 turkeys per acre, but this was found to be insufficient to graze off the available forage. Half this number of birds were ranged on the less intensively grazed area. The Ladino clover was seriously crowded by the orchard grass on both the light and heavily grazed areas. Trampling of orchard grass, which became too large in July before it was clipped, undoubtedly was responsible for considerable smothering and retardation of clover growth on the more intensively grazed plots. This resulted in a lower percentage of Ladino during August and September.

The birds averaged 17.3 and 17.5 pounds with a like ratio of males and females in each of the grazing intensities. Since there was an abundance of forage available this did not affect the grain and mash consumption of either group.

From observation it appears that the maximum number of birds for efficient grazing has not been reached for the heavily grazed areas.

Experiment 2. Evaluation of turkey preference for grasses and legumes.

One hundred and fifty 10-week old poults were turned into a 2-acre field (120 feet by 800 feet) May 22, 1945. It was necessary to remove cuttings of forage on May 1, on account of grass competition for the Ladino. The tall oat grass was

cut once before this date. During the season excessive growth and weeds were kept under control by clipping. The birds were moved daily and it required four weeks to rotate from one end of the field to the other.

The order of preference for grasses was as follows:

	<u>6-5</u>	<u>6-11</u>	<u>6-18</u>	<u>7-3</u>	<u>8-7</u>
Bromegrass.	1	1	1	1	1
Reed canary grass	2	2	2	2	2
Orchard grass	3	3	4	3	3
Tall oat grass	4	4	3	4	4
Kentucky bluegrass	5	6	5	5	5
Tall fescue	6	5	6	6	6

Percentage of Ladino on preference grazing plots obtained from botanical separation:

	<u>5/22- 6/4</u>	<u>6/18- 7/4</u>	<u>7/12- 7/30</u>	<u>8/7- 8/27</u>	<u>9/3- 9/24</u>
Orchard grass	17.7	22.5	24.0	34.4	47.1
Tall oat grass	21.3	32.6	44.5	47.6	47.9
Bromegrass	40.7	53.7	57.7	73.1	77.5
Kentucky bluegrass	49.8	58.5	72.7	79.5	79.5
Tall fescue	24.9	37.6	50.0	52.6	54.2
Reed canary grass	49.7	52.1	54.8	58.1	66.3

On these plots there was a steady increase in the percentage of Ladino from early spring. The turkeys ate the Ladino leaves first, then grass. Reed canary grass made the most uniform all-season growth.

PASTURE RENOVATION EXPERIMENTS (WITH CONNECTICUT)

Title: Grassland Renovation Trials in Connecticut.

Leaders: For the Storrs (Connecticut) Agricultural
Experiment Station - B. A. Brown and
R. I. Munsell.
For the Pasture Research Laboratory - V. G.
Sprague and R. R. Robinson.

1. In this experiment 80 plots involving five treatments and four seed mixtures were seeded on field M in the spring of 1943. In 1945, stands of the several species were estimated in August and yields were determined in June and August.

Results. There was somewhat less Ladino clover on the "disked" than on the untilled "manure" and "weed killer" plots. The yields of dry matter, however, were again considerably (over 25 percent) higher on the disked plots.

Birdsfoot trefoil had increased remarkably since 1944 and was very conspicuous in late June on all plots where seeded. Regardless of renovation practices, the trefoil plots yielded more in 1945 than any of the three Ladino seedings. However, trefoil did not make as much growth after the June cutting as Ladino.

2. Tests of weed killers to reduce competition of perennial grasses to seeded legumes in renovation of pastures.

Over 400 plots, 10 feet square, were included in these tests in 1945. The materials included: sodium arsenite (gray), activated arsenicals, Dow weed killer, ammonium thiocyanate, "atlacide", "ammate", zinc chloride, zinc sulphate, copper sulphate, cyanamid (powdered and granular), sulphuric acid, muriate of potash, and 2, 4-dichlorophenoxyacetic acid. A few of the weed killers were applied on several different dates and all were tested at various rates.

Results. At 100 and 200 pounds per acre ammonium thiocyanate, atlacide and sodium arsenite gave fair to good kills of grasses. Better kills were obtained from spring and fall than summer applications. At the rates used the other materials did not retard the grasses enough to be satisfactory for the purpose.

PASTURE RENOVATION EXPERIMENTS (WITH MASSACHUSETTS)

Title: Grassland Renovation Experiments in Massachusetts.

Leaders: For the Massachusetts Agricultural Experiment
Station - W. G. Colby.

For the Pasture Research Laboratory - V. G. Sprague.

The renovation experiments laid out in 1943 and 1944 began to produce results of an interesting as well as a practical, useful nature during the growing season of 1945. Growing conditions throughout the season were unusually favorable so that herbage yields were exceptionally high in all cases where it was possible to get some measure of production. Some of the procedures which were followed and some of the

results which were obtained will be given for each of several different farms. The report for each farm is in no sense a complete "case history" but it is intended to be full enough to illustrate some of the important points and principles which have developed during the course of these experiments.

Brown Farm - Easthampton, Massachusetts

The field selected for renovation was of no value at the outset as a pasture. A number of pine stumps together with some sapling growth had just been removed and the remaining vegetation consisted of moss, cinquefoil, some low-growing woody plants and poverty grass. The land was first worked with a bog harrow in the fall of 1943. The bog harrow proved to be a very effective tillage instrument in this case notwithstanding the presence of root, sapling stubs and some stones. In the spring of 1944 the piece was fitted with a regular harrow. Lime was applied at the rate of 1-3/4 tons per acre as well as a 3-12-5 fertilizer at the rate of 1,000 pounds to the acre. A seeding mixture of red clover, alsike, Ladino clover, timothy and smooth brome grass was seeded with a light sowing of oats the latter part of April.

The results for the first season were most disappointing. The stand of clovers and grasses was poor and scattered and the few plants which did grow lacked vigor. The only grazing the field produced was from the companion crop of oats and this was poor. By fall some annual weeds had come in and the whole project looked like a total failure.

In an effort to salvage something from the experiment, more fertilizer (500 pounds of a 5-15-20 grade) was applied in the fall of 1944 and more grass and legume seed (well inoculated) was scattered over the whole field early in March 1945. The results as shown by the following grazing record for 1945 were astonishing:

<u>Grazing period</u>	<u>Number of days</u>	<u>Number of cows grazed</u>	<u>Number of hours per day</u>
May 26-June 3	9	13	2-3
June 14-June 28	11	12-13	2-4
July 2-July 22	9	11-12	2-4
August 17-August 24	6	11	4-7
September 9-September 11	2	11	3-4
September 11-October 1	19	3 (heifers)	9

The number of cow days of grazing produced per acre can be conservatively estimated at from 350 to 400.

To the combined effects of limited rainfall following a spring seeding the latter part of April, of poor nodulation of the legumes, and of a seedbed of rather poor tilth may be ascribed the limited establishment and the reduced yield of forage from this field in 1944. However, fall rains and additional fertilizer aided the plants which had become established so that they went into the winter in fair condition. The favorable weather during the winter, spring, and summer of 1945, and the seed sown early in March provided abundant herbage throughout the season.

Taylor Farm - South Ashfield, Massachusetts

The area selected for renovating was steep land with slopes running up to 25 percent in grade. It was part of an old permanent pasture which, though depleted, still supported a fair bentgrass sod. Some large rocks were present. The land was bog harrowed in the early summer of 1944 and after liberal applications of lime and fertilizer was seeded in late August. An excellent stand of grass and clover was secured immediately and no winter injury resulted the following winter. Growth during the summer of 1945 was excellent. This area, one acre in size, together with about three other acres which Mr. Taylor had renovated on his own initiative, supplied most of the grazing for from 14 to 18 cows throughout the pasture season.

The outstanding feature of this experiment was the effectiveness of the bog harrow in working up old depleted permanent pasture land with steep slopes and only a moderate number of rocks. A suitable seedbed was prepared and notwithstanding a heavy beating rain which came a few days after seeding, soil losses from water erosion were insignificant.

Harlow Farm - Amherst, Massachusetts

The renovated area in this case was level but the land was covered with rocks of various sizes. There was a good bluegrass sod on part of the field but hardhack and sheep laurel were abundant on the remainder. The soil was a very fine sandy loam underlaid with an impervious clay. Drainage, particularly in the early spring, was poor.

The land was worked with a bog harrow in the fall of 1943 but, because of an abundance of stones, this machine was not effective. In the summer of 1944, most of the surface stones were removed and a bog harrow was again tried. A seedbed was

prepared but only after working the field both lengthwise and crosswise. Lime was applied at the rate of two tons to the acre and a 5-15-20 fertilizer at the rate of 1,000 pounds per acre. Part of the field was seeded in mid-August and part the following spring in March.

The midsummer seeding was much more successful than the one made the following spring. The poor drainage conditions were probably responsible for this. The summer seeding made excellent growth during the summer and fall and had produced a fairly heavy sod before freezing weather. Growth was resumed the following spring and maintained throughout the growing season even though the land was very wet at times. The early spring seeding started very slowly and did not make much growth until midsummer when the land had dried up. The summer seeded section produced 6500 pounds of dry matter per acre, the spring seeded section not more than one-fourth as much.

The two sections also differed markedly in the extent to which Kentucky bluegrass recovered in each one. Notwithstanding a late fall harrowing of the spring seeded part, a fairly extensive recovery of grass occurred during the cool, moist fall period. Because of strong competition from the new seeding on the summer seeded part, there was very little recovery of the old grass.

If an old sod is worked up one summer for seeding the following spring and if it is not too well killed, it would be wise to plant some sort of cover crop such as oats or barley in the early fall to retard the recovery of the old turf.

PASTURE RENOVATION EXPERIMENTS (WITH PENNSYLVANIA, AT MONTROSE,

AND

DIVISION OF FORAGE CROPS AND DISEASES)

Title: Pasture Renovation Trials in Northeastern Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - S. I. Bechdel and J. K. Thornton.
For the Division of Forage Crops and Diseases - S. R. Skaggs and M. A. Hein.
For the Pasture Research Laboratory - V. G. Sprague.

This second-year harvest from seedings made on cultivated and well-fertilized permanent pasture sod bears out the statement made last year that the species of grass has a relatively slight influence on the yields of green forage.

Timothy, orchard grass, smooth brome grass and a combination of all three gave somewhat higher yields than Kentucky bluegrass or a seeding of legumes without grass.

Ladino clover, alfalfa and birdsfoot trefoil were the only legumes in the original seeding which continued to be of any importance. Ladino clover is probably superior to any of the legumes from the standpoint of season-long production of palatable grazing. Ladino clover with orchard grass and with a combination of timothy, orchard grass and brome grass yielded more than 5,000 pounds of air-dry forage before July 15. These plots maintained a superior production from that date to the end of the growing season.

For summer grazing it appears that Ladino clover is the outstanding legume and orchard grass is superior to other grasses. Both continue to grow well during hot, dry weather and both make quick recovery after being grazed or mowed at any time of the year.

PASTURE RENOVATION EXPERIMENTS (WITH PENNSYLVANIA, AT STATE COLLEGE)

Title: Pasture Renovation Trials in Central Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment
Station - A. W. Clyde, J. K. Thornton, and C. O.
Cromer.

For the Pasture Research Laboratory - V. G. Sprague
and R. R. Robinson.

The first renovation experiment at State College (1943 Annual Report, pages 11 to 13, and 1944 Annual Report, pages 22 and 23) was continued during 1945. Three cuttings were made of the Ladino-grass, alfalfa-grass, and red clover, alfalfa, Ladino clover-grass mixtures and two cuttings were made of the red clover-grass, Lotus-grass, and sweet clover-grass mixtures. All yields in 1945 were higher than in 1944 due in considerable part to more favorable rainfall. The average yield of the alfalfa-grass mixtures again outyielded all other legume-grass mixtures by producing about 7400 pounds of dry matter per acre. The second highest yields were produced by red clover (third year), Lotus, and the red clover-alfalfa-Ladino clover mixture which produced approximately 5500 pounds of dry matter per acre as an average with all grass mixtures. Ladino clover yielded 4500 pounds of dry matter per acre and the sweet clover (which was reseeded in March 1945) yielded 2800 pounds of dry matter per acre. Similar to 1944, the species of legume used in a mixture seemed to be a more important factor in determining the

yield of the mixture than the grass species. Lotus was vigorous in this, the third year, as is evidenced by its yield which compared favorably with red clover, alfalfa, and Ladino clover. One shortcoming of this species would appear to be its limited midsummer recovery--the major proportion of its yield being in the first crop harvested during the latter part of June.

During 1945 weather was favorable for the growth of the plots top-dressed with lime, phosphorus, and potash, and a heavy growth of white clover resulted. During 1943 and 1944, the top-dressed plots yielded only slightly more than the untreated area, but during 1945 these plots yielded about 3500 pounds of dry matter per acre compared to 1,000 pounds of dry matter for the check area. As has been evident for the past several years, the improvement of a poor pasture sod by top-dressing with mineral fertilizers is much slower than when an area is renovated by applying fertilizer, disking thoroughly, and reseedling.

The results from studies on several methods of seedbed preparation in this experiment as well as in the second renovation trial seeded in 1944 (1944 Annual Report, pages 23 and 24) indicate that no appreciable differences in yield of herbage due to method of seed preparation occur after the year of seeding.

Plots in the grass and legume species trials seeded in March 1944 (1944 Annual Report, pages 24 and 25) were harvested either two or three times during 1945 as growth of the several species dictated. A summary of the growth responses of the various grass species and the legume associations are presented in Table 4. It will be noted in the legume associations that the total yields of the several legume species cover a considerable range but that the yields of the grass species are fairly uniform except for tall oat grass which is above average and brome grass which is below. The yield of legumes is accordingly low with tall oat grass, probably due to competition, whereas the yield of legumes in association with brome grass is slightly above average.

During the 1945 season leaf hopper injury to alfalfa was especially severe which may account in part for a somewhat lower yield than might be expected. It is probable that in 1946 the yields of the mixtures including red clover will be lower whereas those mixtures including birdsfoot trefoil will be higher.

Table 4. Summary of the growth responses of the various grass species and the legume associations.

Species or mixture*	Per	Average yields of dry		
	cent	matter per acre		
	:grass**:	Total	Legumes:	Grass
Red clover, alfalfa, Ladino	: 47	: 5910	: 3157	: 2743
Red clover, Ladino	: 50	: 5505	: 2990	: 2602
Alfalfa, Ladino	: 66	: 4698	: 1560	: 3103
Birdsfoot trefoil	: 66	: 4575	: 1543	: 2954
Birdsfoot trefoil and sweet clover	: 66	: 3709	: 1434	: 2238
Timothy	: 38	: 5584	: 3112	: 2454
Reed canary grass	: 49	: 5355	: 2740	: 2596
Tall oat grass	: 75	: 5170	: 1418	: 3734
Tall fescue	: 52	: 5035	: 2482	: 2511
Orchard grass	: 65	: 4740	: 1829	: 2875
Bromegrass	: 43	: 4663	: 2792	: 1836

* The legumes were grown in combination with each of the six grasses and the grasses were grown with each of the five legumes or legume combinations.

** Average of all cuttings for 1945 season.

Time and Rate of Seeding. In the summer of 1944 an old pasture sod was limed, fertilized, and disked to prepare a seedbed for use the following spring. In 1945 seedings were made March 12, April 10, and May 15. Five associations of red clover, Ladino clover, and orchard grass which varied in the amount of seed used from six pounds of red clover, one pound of Ladino clover, and eight pounds of orchard grass per acre down to three pounds of red clover, one-half pound of Ladino clover, and three pounds of orchard grass per acre. In addition, four associations of alfalfa, Ladino clover, and timothy at various seeding rates were all sown with and without a companion crop of oats on April 10 and May 15. Where oats were used, they were mowed just prior to flowering. Total yields of herbage were obtained (Table 5) and botanical separations were made from each plot to determine the contributions toward total yield of the several species in the mixtures. It is apparent from the summary Table 5 that the earlier the seeding date in the spring, the greater was the total yield during the seeding year. Even more striking is the reduction in yield of the forage species when seeded with a companion crop of oats even though the total yield was not critically reduced.

Table 5. Yield responses of two forage mixtures as affected by date of seeding with and without a companion crop of oats cut for hay.

		Yield of dry matter, pounds per acre			
		First cutting	Aftermath:		
		Oats	Forage species	forage species	Total
Seeding dates		Alfalfa-timothy			
March 12		-	2906	629	3535
April 10		-	2600	371	2971
April 10		1639	312	-	1951
May 15		-	1114	-	1114
May 15		2184	98	-	2282
		Red clover-Ladino clover-orchard grass			
March 12		-	2842	1058	3900
April 10		-	2560	1294	3854
April 10		1906	114	924	2944
May 15		-	1237	-	1237
May 15		1881	86	-	1967

PASTURE RENOVATION EXPERIMENTS (WITH RHODE ISLAND)

Title: Pasture Renovation Trials in Rhode Island.

Leaders: For the Rhode Island Agricultural Experiment
Station - Irene H. Stuckey and Avery E.
Rich.
For the Pasture Research Laboratory -
V. G. Sprague.

On the renovation area seeded in the spring of 1944, yields were calculated from samples of forage cut immediately before each grazing period in addition to the number of cow days grazing per acre. The total yields from five cuttings and the proportions of the yields due to the grasses, the legumes and the weeds are shown in Table 6.

It was observed that along the edges of the renovation plot, the old bluegrass sod had begun to encroach on the tall grass-legume seeding, further emphasizing the need for thorough working of the sod prior to seeding if the renovated pasture is to remain productive.

Table 6. 1945 yields of grass-legume mixtures on a pasture renovated in 1944.*

Mixture planted, pounds per acre	Total green:		Pounds per acre of		Hay		
	weight,	:	components calculated	:	equivalent		
	pounds	:	from dry weights	:	pounds		
	per acre	:	Grass	: Legumes	: Weeds	: per acre	
Alfalfa 7, timothy 3, Ladino 2, brome grass 8 (essentially a brome grass-Ladino mixture)	35,424	:	11,123	:	22,778	: 1,594	: 7,441
Red clover 3, alsike 2, timothy 3, Ladino 2, reed canary grass 6 (essentially reed canary grass- Ladino mixture)	44,507	:	15,577	:	27,594	: 1,557	: 8,523
Red clover 6, Ladino 2, orchard grass 6 (only orchard grass- Ladino showed in this mixture)	37,075	:	18,575	:	17,129	: 1,557	: 7,588

* Total cow days per acre - 262.

In August 1944 an old sod area which had received no lime, fertilizer or manure for at least ten years was thoroughly disked. The original vegetation consisted for the most part of a thin sod of bentgrass. The topsoil is a fine sandy loam of the Naragansett series, underlaid with gravel. The area is typical of much of the pasture land in Rhode Island and was renovated for the express purpose of determining if such lands could be made productive enough to warrant the expense of renovation. The mixtures seeded and the total yields obtained from two cuttings during the summer of 1945 (the seedling year) are shown in Table 7.

PASTURE RENOVATION EXPERIMENTS (WITH VERMONT)

Title: Pasture Renovation Trials in Vermont.

Leaders: For the Vermont Agricultural Experiment Station
- A. R. Midgley and K. E. Varney.
For the Pasture Research Laboratory - V. G.
Sprague.

Relative Value of Different Plants for Renovation. The following legume-grass combinations are being studied for pasture reseeding and renovation: alfalfa-bromegrass; red and alsike clover-timothy; sweet clover-reed canary grass; Ladino clover-orchard grass; and birdsfoot trefoil-timothy. All of these plants did well on reasonably good pasture land which was disked, well limed and fertilized. The production of forage from the different seedings was in the order given above. After the second year, red and sweet clover practically disappeared but the alfalfa-bromegrass plot continued to be outstanding. Ladino clover winterkilled quite badly the first year, but it reseeded sufficiently to make a good stand. Birdsfoot trefoil grew very slowly the first year and the unkilld original vegetation gave it considerable competition. However, the stand is thickening up considerably and is now doing much better. The ease of establishing different legumes for pasture renovation purposes (where the seedbed is not ideal) seems to be in the following order: red clover, sweet clover, alfalfa, Ladino and birdsfoot trefoil. Even though all the original vegetation is not killed by disking and a poor seedbed is prepared, reasonably good stands of red clover can be obtained but a complete failure usually results with birdsfoot trefoil.

Table 7. Yields of grass-legume mixtures in a renovated pasture during 1945, the year of seeding.*

Mixture planted, pounds per acre	: Total green: Pounds per acre of					: Hay	
	: weight,		: components calculated			: equivalent	
	: pounds		: from dry weights			: pounds	
	: per acre		: Grass : Legumes : Weeds			: per acre	
Bromegrass 8, alfalfa 8, Ladino 1	: 14,031	:	: 1,656	: 5,963	: 6,482	: 3,109	:
Orchard grass 4, alfalfa 8, Ladino 1	: 13,770	:	: 3,718	: 5,563	: 3,787	: 3,349	:
Bromegrass 8, Lotus 4, sweet clover 8	: 16,036	:	: 1,379	: 9,509	: 5,324	: 3,353	:
Timothy 5, alfalfa 8, Ladino 1	: 14,728	:	: 4,551	: 7,025	: 3,873	: 2,828	:
Tall fescue 6, Lotus 4, sweet clover 8	: 16,471	:	: 3,360	: 8,284	: 4,530	: 3,538	:
Orchard grass 4, Lotus 4, sweet clover 8	: 16,123	:	: 3,418	: 7,965	: 2,854	: 3,884	:
Tall fescue 6, alfalfa 8, Ladino 1	: 15,077	:	: 4,870	: 5,759	: 4,447	: 3,239	:
Timothy 5, red clover 6, Ladino 1	: 16,210	:	: 5,074	: 7,992	: 3,145	: 3,482	:
Orchard grass 4, red clover 6, Ladino 1	: 18,040	:	: 7,432	: 5,935	: 4,672	: 3,957	:

* Total cow days per acre - 89.

Disking vs. Plowing for Pasture Renovation. In a 4-acre field of run-down, stone-free pasture, a number of strips were plowed and the remainder disked. One-acre plots across the plowed or disked strips were laid out and each seeded as follows: alfalfa-bromegrass; red, sweet clover-timothy; birdsfoot trefoil-timothy; and Ladino clover-reed canary grass. The disked area was worked several times with a cutaway disk but much of the original grassy vegetation was not killed. It is now evident that more time should elapse between diskings so that the old vegetation would dry out and die.

The following yield data were obtained from the plowed and disked areas:

	Yield, pounds per acre		Increase from plowing
	<u>Plowed</u>	<u>Disked</u>	
Alfalfa-bromegrass	7,750	6,740	1,010
Red, sweet clover-timothy	7,730	7,480	250
Ladino-reed canary grass	6,360	5,620	740
Birdsfoot trefoil-timothy	5,660	5,190	470

These results indicate that on land which can be plowed and where erosion is not a factor, it is better to plow than to attempt diskings unless a good diskings job can be done. At the close of the season, differences in the establishment of the seeded species resulting from these two methods of soil preparation appeared to be less marked. Plowing prepares a good seedbed and kills most of the old vegetation. Disking is equally satisfactory when it is done at a time of year and in such a manner that the existing vegetation will dry out and die. By diskings a firm seedbed is prepared and more organic matter is left on the surface as a protective mulch for the new seeding. This mulch reduces erosion and prevents the surface soil from slacking and puddling during heavy rains.

Time of Seeding. Different grasses and legumes were seeded at three different dates on fall-disked land. All seedings made on frozen ground in late fall (November 20) were much poorer than similar seedings on frozen ground in early spring (March 15). Both were somewhat poorer than plantings made with regular seeding machinery about May 15. However, there is considerable advantage in seeding pastures in early spring on frozen ground: the spring rush of labor is spread over a longer period, plantings usually become established before drought overtakes them, and earlier pasturage is assured.

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING

Fertility Studies in Dactylis glomerata

Inheritance of Male Sterility in Dactylis glomerata. In the material described previously (1944 Annual Report, page 30), a total of 6483 plants of F_2 , test cross and backcross progenies were classified for male sterility. The data were all consistent with the hypothesis that male sterility in this investigation was conditioned by the interaction of a dominant gene, M , with a male sterile cytoplasm. The results indicate that plants from seed produced on male sterile plants were sterile if quadruplex, triplex or duplex for the sterility gene (i.e., M_4 , M_3m_1 or M_2m_2) fertile if nulliplex (m_4), and either sterile or fertile if simplex (M_1m_3). Among the F_1 plants studied in test and backcrosses, seven proved to be simplex. Of these, three were fertile and four were male sterile. The ratios obtained in most test and backcross progenies agreed well with those calculated on the assumption that simplex plants were sterile and fertile in equal frequency. The few exceptional ratios obtained could be explained by the assumption of modifying factors that changed the proportion of sterile and fertile plants in the simplex class.

The fertile parents used in the two original crosses proved to be triplex (M_3m_1) indicating that the gene does not condition male sterility in the absence of the appropriate cytoplasm. That the effect was cytoplasmic, not maternal, was indicated by recovery of male sterile plants in the expected frequency from intercrossing two fertile F_1 plants known from other breeding tests to be simplex.

The feasibility of utilizing this type of male sterility in the plant breeding program for the production of hybrid seed will depend in part upon whether the gene has adverse effects, other than sterility, upon the plants. In progenies segregating for male sterility and fertility, the sterile segregates were indistinguishable morphologically from the fertile segregates.

To test the validity of the hypothesis and to study the effects of modifying factors on expression of male sterility in simplex (M_1m_3) plants, a series of test crosses, using two plants known to be nulliplex (m_4) as testers, has been planned. The clones for making the crosses are being grown in the greenhouse, the crosses will be made during the winter of 1946, and the progeny plants planted in the field in the spring of 1946.

An abstract peresenting the results of these investigations to date has been prepared for presentation at the meetings of the Genetics Society in 1946.

Effects of Inbreeding on Fertility in *Dactylis glomerata*.

Using replicated clones of inbred plants from three first-inbred-generation progenies of orchard grass, established for studying the effects of inbreeding on irregularities of meiosis (1944 Annual Report, page 43), studies of the effects of inbreeding upon self- and cross-fertility are being carried out. Numbers of spikelets per panicle have been determined and, in two progenies, there were significant differences among inbred clones in this character. In the third progeny the differences were not significant. Number of seeds per panicle with self- and open-pollination have been determined and are being studied, by analysis of covariance, in relation to number of spikelets per panicle, height of plant, and date of heading. These analyses have not yet been completed.

Varietal Improvement in *Dactylis glomerata*
Poa pratensis, *Festuca elatior*, *Bromus inermis*,
Trifolium repens and *Medicago sativa*

Inbreeding in *Dactylis glomerata*. Selected plants were self-pollinated in 43 I₁, 34 I₂, 25 I₄ and 23 F₃ lines that were established in the nursery in the spring of 1944 (1944 Annual Report, page 31). The seed set obtained on these plants has not yet been recorded. Progenies of plants from which sufficient seed was obtained will be established in the nursery in the spring of 1946 for continuation of inbreeding in these lines.

The selfed seed obtained from I₃ lines in the summer of 1944 (1944 Annual Report, page 31) was used in the spring of 1945 for a field planting designed to provide polycross seed for testing the effects of four generations of inbreeding on combining ability and for studying the segregation of combining ability in the first inbred generation. For use in this study, 60 I₄ lines from 17 families (6, 6, 5, 5, 5, 4, 4, 4, 3, 3, 3, 2, 2, 2, 2, 2, 2, lines per family) were available. The inbred plants and plants of the original parental clone were placed in the same row in each replication and the rows were arranged in 10 replications with randomization restricted to prevent two lines from the same family occurring in adjacent rows. Open-pollinated seed will be harvested from each inbred line and each parental clone and the seed will be planted in plots in association with Ladino clover. From I₁ lines established in the nursery in the fall of 1941 and selfed in 1944, 64 I₂ lines were transplanted to the nursery in the spring of 1945.

Hybridization and Recombination of Characters in *Dactylis glomerata*. Among the many thousands of orchard grass plants that have been examined in the breeding nursery over a period of years, not a single plant has been found combining superiority for all or even several of the desired characteristics. For example, all late maturing plants have proved to be deficient in seedling vigor, to be subject to winter injury, and to start growth late in the spring. The most expeditious method of obtaining combinations of desirable characters in single lines would seem to be by hybridization followed by selection among segregating progenies in succeeding generations. During the winter of 1944-45, 25 selected clones were used in appropriate crosses, i.e., in crosses involving clones with complementary characters. Seed was obtained in 60 crosses and, from these, F_1 plants were established in the nursery in the spring of 1945. It is proposed to inbreed in at least part of these families by sib mating of selected F_1 plants and to select within the segregating progenies for the desired combination of characters.

It has been proposed by some plant breeders that, where selected clones with complementary superior characters are grown in a polycross block, the polycross seed progenies of the various clones will provide the best source of selections combining several of the superior characters. As a test of this possibility, space-planted polycross progenies of each of the 25 clones were included in the nursery with the F_1 plants from intercrosses of the clones.

Comparison of Clonal and Polycross Progeny Tests for Evaluation of Individual Plants of *Dactylis glomerata* and *Trifolium repens*. For several years, the evaluation of individual plants of grasses and legumes by use of vegetative increases has been investigated. The results have shown that, by spacing plants of each clone at appropriate intervals in individual plots, seeding the proper associated species broadcast over the plot area, and management by mowing to simulate conditions of actual use, a grass-legume association can be established and maintained that appears quite comparable to the association obtained when both species are seeded. In tests of this type, significant differences among clones in persistence, aggressiveness, growth habit, yield and other characters have been demonstrated. It is recognized that this provides a test of the phenotypic responses of the clone whereas the value of the clone in production of varieties or hybrids rests upon its breeding behavior, i.e., upon its genotype. The validity, therefore, of utilizing clonal tests for evaluating plants in the breeding program is contingent upon the degree to which the phenotypic responses of the clone reflect its genotypic constitution.

To provide information on this problem, tests have been arranged in orchard grass, Ladino clover, and common white clover, using polycross progenies of the selected clones for testing their breeding behaviors. For the tests in orchard grass, 15 clones were selected from one of the maturity groups in the 1942 polycross block (1942 Annual Report, page 7). These clones were representative of the range in vigor and other characteristics among the clones of this maturity group. In Ladino and white clover, 11 of the best and 4 below average clones were selected from the polycross plots (1944 Annual Report, page 33). In the tests with each species, a commercial check was included and, for comparison with the clonal plantings, seedlings were established from the commercial seed and the seedlings transplanted to the appropriate plots using the same spacing as for the clones. In each species, the seeded and clonal plots, respectively, were arranged in 4 by 4 lattice designs with 4 replications and the replications interplanted so that a replication of seeded plots was paired in each case with a replication of clonal plots. The spacing of clones within plots was 9 by 9 inches for orchard grass and 12 by 12 inches for Ladino and white clover. A uniform broadcast seeding was made of Ladino clover in the orchard grass plots, orchard grass in the Ladino clover plots, and Kentucky bluegrass in the white clover plots. All plots were mowed uniformly during the summer of 1945 to suppress weed growth and to foster establishment of the planted and seeded species.

Reaction of Varieties of *Dactylis glomerata* and *Medicago sativa* to Systems of Management and Associated Species.

Orchard grass may be used in the forage program in various ways and in combination with various legumes. Thus, if varieties of orchard grass respond in a differential manner to systems of management and to the associated legume, it will be necessary in the breeding program to evaluate new varieties with each of the systems of management and in combination with each legume with which it may be used in practice.

To obtain information on this important question, an experiment was started in the spring of 1945 using eight varieties, two management systems, and two associated legumes. The varieties selected were commercial, Brage, Finnish late hay, Avon, Hercules, and three new strains from the cooperative breeding program (page 4 of this report). In one system of management, the herbage will be mowed to 3 inches when it reaches 8 to 10 inches throughout the growing season. In the other treatment, the first crop will be harvested for

grass silage (late boot or early head stage) followed by mowing from 8 to 10 inches back to 3 inches for the remainder of the growing season. The associated legumes were Ladino clover and alfalfa.

The plots were mowed uniformly during 1945 to suppress weed growth and foster establishment of the plots. It is planned to start the treatment differentials in the spring of 1946 and to take yield data at each harvest date.

A similar problem of interaction of varieties with systems of management and with associated species is encountered in the alfalfa breeding program and, consequently, an experiment comparable to the one described for orchard grass was established with alfalfa. Six varieties were used, namely, Hardistan, Buffalo, Ranger, Atlantic, Grimm and Kansas Common. Four treatments are planned:

1. Seeded alone to be harvested for hay.
2. Seeded alone, the first crop harvested for hay and succeeding crops cut from 10 to 3 inches.
3. Seeded with orchard grass and clipped as in 2.
4. Seeded with orchard grass and clipped throughout the season from 10 to 3 inches.

Strain Trials of *Poa pratensis*. The experiment described previously (1942 Annual Report, pages 19 to 23, 1943 Annual report, page 26, and 1944 Annual Report, pages 34 and 35) was continued. The plots were clipped five times during 1945 on April 17, May 26, June 18, July 26, and October 30. Data from the fifth clipping have not yet been analyzed so analyses of the data for the year are not completed. In the information summarized to date, several points are evident, however:

1. Contrary to results reported by some other investigators, strain differences, similar to those obtained in the first harvest year, have been obtained throughout the four years of the experiment.
2. The strains were significantly different in percentage of associated white clover but much of this difference was attributable to variations in yield of bluegrass. There were, in fact, at some harvest dates no significant differences in calculated yield of white clover on plots of different bluegrass strains.
3. During the course of the experiment there was a considerable ingress of weeds, particularly dandelion and broad leafed plantain. The percentage of weeds and calculated

yield of weeds were negatively correlated with yield of bluegrass to such an extent that, at some harvest dates, this factor obscured differences in yield among strains. Whereas the strains were significantly different in yield of bluegrass plus white clover, the differences in total yield (including weeds) were not statistically significant in some harvests.

4. So far as indicated by these data, total yields, when weeds were not a serious factor, gave fairly reliable information on differences in productivity of the bluegrass strains. With the complication of differential ingress of weeds, however, reliable evaluation of the productivity of the bluegrass strains can be made only if data are available on botanical composition of the herbage. It seems probable that in some experiments similar complications would result from differential amounts of clover.

5. The interaction of clipping treatment x strains has never been statistically significant for total yield of herbage, yield of bluegrass, yield of white clover or yield of weeds. At only two harvest dates in four years has this interaction been significant for percent of clover and in these cases the F value was relatively small. The strains included in this experiment represent a wide range of morphological types. The results suggest that within the limits of good management, the height and intensity of clipping may not be a serious differential factor in evaluating strains of Kentucky bluegrass.

6. Despite the fact that these strains of Kentucky bluegrass had been selected previously because of superior performance (seed formation, compatibility with white clover, estimated yield, etc.) in plots associated with white clover, few of the 13 were superior to the two commercial checks in yield of bluegrass and in total yield. In fact, only KB143(223) has proved rather consistently superior. Some strains were distinctly less productive than commercial. There are two possible explanations for the failure of the selected clones to be more productive than commercial. In the first place, estimates of yield may be subject to too great inaccuracy so that selection in the preliminary plots was relatively ineffective. A second possibility is that the mixture of types, found in commercial lots, may be superior in productive capacity to single types of plants grown alone. This latter possibility can be tested experimentally (see following).

Evaluation of Pure and Mixed Strains of *Poa pratensis*. To test the second alternative postulated above, five strains were selected from among the 13 included in the experiment just described. Two strains were tall growing, long leaved, relatively coarse types producing an open type of sod. These two were the highest yielding of the 13 strains during four years of testing. Two strains had short leaves, were relatively low-growing and dense sod formers. The yield of each of these strains was significantly lower than commercial. The fifth strain more nearly resembled the first two in growth habit but formed a denser sod, was more competitive with white clover and weeds, and was characterized by high spring and low midsummer yield.

Plots were seeded in the spring of 1945 with each strain alone and with mixtures, two strains in all possible combinations of the five strains, three strains in all possible combinations, four strains in all possible combinations, and all five strains. This made a total of 31 single strains and combinations and a commercial seed lot was included for a check. Six replications were used and the entire area was seeded uniformly with Louisiana white clover. The area was mowed periodically during 1945 to suppress weed growth and encourage development of the bluegrass and white clover.

Response of Strains of *Poa pratensis* to Nitrogen Fertilization and Height of Clipping. The plots described previously (1943 Annual Report, pages 26 and 27) were clipped uniformly at intervals during 1944 to foster establishment of the grass-legume association. Nitrogen fertilization and treatment differentials were started in the spring of 1945 and dry weights of harvested herbage were determined at each clipping date in 1945. Because of the ingress of volunteer white clover in the plots originally established to be "no clover" plots, it was necessary to change the plan of the experiment. This was accomplished readily by substituting heights of clipping for the "clover-no clover" differential. One set of plots was clipped to one inch when the herbage reached an average height of 4 to 5 inches and the other set was clipped to two inches when the plants reached 5 to 6 inches. On the fertilized plots, nitrogen was applied early in the spring and immediately following each clipping at the rate of 40 pounds of nitrogen per acre except during dry weather when the rate was reduced to 30 pounds.

The unfertilized plots were obviously greatly deficient in nitrogen and a poor growth of grass was obtained. In general, the strain differences were smaller and much less striking in the no-nitrogen plots than in those receiving nitrogen. It is planned to continue this experiment during 1946.

Evaluation of Plant Types in *Poa pratensis*. The observation plots of new strains of Kentucky bluegrass (1943 Annual Report, page 24) were continued. Seed of new strains was harvested during the past summer and there is now on hand seed of 72 new strains ready for testing in preliminary plots when facilities become available for the tests.

Production of Improved Strains of *Festuca elatior*.

Additional seed was harvested from the 15 isolation plots of meadow fescue (1943 Annual Report, page 27). Because of limitations of space and labor, the proposed plots of these strains (1944 Annual Report, page 35) were not seeded in the spring of 1945. It now appears that it will be impossible to seed the plots in the spring of 1946. The seed will be stored until facilities become available for testing these strains.

The crown rust immune plants from additional seed collected by Doctor F. H. Steinmetz from near Orono, Maine (1944 Annual Report, page 35), proved upon cytological analysis to be hexaploid instead of diploid as expected. Reexamination verified previous findings that the immune plants reported previously from this locality were diploid. Some of the hexaploid plants were infected with rust when inoculated in the greenhouse.

Production of Improved Strains of *Bromus inermis*. Additional seed was harvested from each of the four isolation plots (1943 Annual Report). It is hoped that facilities will be available in the spring of 1946 for establishing plots of these strains for testing in comparison with presently available brome grass varieties.

From the source nursery of approximately 5,000 plants (1943 Annual Report, page 27), 173 were selected on the basis of vegetative vigor, leafiness, resistance to lodging, disease resistance and recovery following mowing. The selected plants included a wide range of types as regards maturity date, growth habit and rhizome development. These plants were increased vegetatively in the fall of 1945 and the clones were transplanted to the nursery in 15 replications for the production of polycross seed.

Inbreeding in *Trifolium repens*. Chiefly on the basis of resistance to *Pseudopeziza* leaf spot, plants from 45 of the 156 I₃ and I₄ white clover lines established in the nursery in the spring of 1944 were selected for further selfing. For each of these lines, the most disease-free plant was selfed in each of the six replications with the hope of obtaining enough seed for the establishment of a further polycross test of these selected lines.

The 70 I_2 self-fertile white clover lines established also in 1944 were subjected to the same selective process as the I_3 and I_4 lines. The most disease-free plant from each of the three replications of 38 selected lines was selfed. The seed obtained will be planted to produce progeny for further selfing.

Genetic Investigations

Adult Plant Characters in *Dactylis glomerata*. During the summer of 1945 two additional adult plant characters, both dwarfs but phenotypically distinguishable, were isolated from inbred progenies. The ratios obtained indicated that each type was conditioned by a single recessive gene.

Heritable Young Plant Characters in *Dactylis glomerata*. In continuation of the studies of inheritance of young plant characters in orchard grass, 6417 seedlings have been planted in flats and pots during the fall of 1945 and classified for seedling characters such as zebra, virescent, yellow, albino, etc. These seedlings were from 87 I_3 progenies and 36 F_2 . Additional seed is being planted so analysis of the results cannot yet be made.

Size Inheritance in *Trifolium repens*. F_1 plants of two crosses of selected Ladino clover clones x self-fertile white clover clones were selfed and backcrossed to the parent clones in the greenhouse during the winter of 1944-45 (1944 Annual Report, page 37). Parents were again crossed to produce additional F_1 progeny plants.

On the basis of greater size differences between the two parents and better seed production, the parents, F_1 clones, and their F_2 and backcross progeny of one of the two original crosses were selected for continuation of the study. For field planting in the spring of 1945, there were thus available the two parental clones, nine F_1 clones, the F_2 and backcross seed from each of the nine F_1 clones, and additional F_1 seed from the new crosses of the originally selected Ladino and white clover clones.

The size differences between the two parental clones and among the nine F_1 clones, as exhibited by measurements made in the greenhouse on the mean length of the terminal leaflet of the fourth leaf from the tip of the stolon, were found to be statistically significant. The mean of the Ladino parent was 26 mm. and that of the white clover parent 12.7 mm. The nine means of the F_1 clones ranged from 20.2 mm. to 27.4 mm.

Because of the demonstrated heterozygosity of the F_1 material, it is essential that the identity of each F_1 clone, its F_2 and backcross progeny be maintained and that separate statistical analyses be made of data on each group of generations related to their respective F_1 clone. Therefore, in the field planting of this material, in order to reduce the soil variability effect to a minimum, the relatives of each of the nine F_1 clones, i.e., the parents, the F_1 clone itself, the F_2 line, and the backcross lines, were planted in a compact block, nine blocks constituting a replication. The generations were randomized within blocks and the blocks were randomized in 10 replications. A total of 4250 plants was space planted, each individual block consisting of 10 plants from cuttings of the F_1 clone, 20 F_2 plants, a varying number (1 to 6) of backcross plants, and four to five plants of each parental clone.

Measurements of size characteristics will be taken in the spring and summer of 1946.

Inheritance of Leaf Markings in *Trifolium repens*. During the winter of 1944-45 approximately 500 crosses were made in the greenhouse within and between various patterned leaf marking types found in Ladino clover (1944 Annual Report, page 37). These types may be summarized as follows:

1. No marking - the complete absence of any patterned marking.
2. Normal, full single V - light yellow to greenish-white in color.
3. Double V - two more or less distinct V's, the bars of each parallel.
4. V point - only the point of a V visible.
5. Broken V - two more or less curved bars, unjoined at the tip, and of a grayish-white color.
6. Broken V and yellow point - type 5 + a greenish-yellow point, distinct from the V point.
7. Full and broken V - a combination of the single V and the broken V, with the broken V to the outside of the full V.
8. Full and broken V, with yellow point.

9. V point and broken V.
10. V point and broken V, with yellow point.
11. Broad V, bounding a light greenish-white leaflet center.
12. White center - a bright greenish-white V shaped sector at base of leaflet.

Ten-plant progeny rows from most of the 500 crosses were planted in the field in the spring of 1945. By the end of summer classification on a total of approximately 3300 plants was completed.

With the goal of obtaining self-fertile homozygous leaf marking types, the 1944-45 greenhouse plants of the various marking types were crossed with a heterozygous self-fertile plant of the no marking type (one of the F_1 clones used in the size inheritance study). Twenty progeny of each of these crosses were planted in the field and classified. Approximately 350 of these plants were selfed in the field. Progeny from those found to be self-fertile will be grown and classified in 1946.

Concerning the genetics of the various leaf marking types only tentative hypotheses can be advanced. Additional data from intercrossing the F_1 progeny and backcrossing to both parents will be necessary for the clarification of the genetic interactions. F_1 plants showing the different kinds of leaf marking segregations and the parents of these F_1 plants were brought into the greenhouse for the execution of such a program during the winter of 1945-46.

In crosses involving the single V, broken V, and V point with the no marking types, the results indicated that in each case presence of marking was differentiated from no marking by a single dominant factor. Results in all crosses were consistent with the hypothesis of five multiple alleles conditioning presence of marking, viz., (1) V^L and V^H which condition full V markings and which together result in a double V, (2) V^B which conditions the broken V and which the V^L or V^H conditions a full plus broken V, (3) V^P which conditions the V point, and (4) V^{BP} which conditions the broken V plus the yellow point.

Cytological Investigations

Origin of Aneuploidy in *Dactylis glomerata*. The chromosome numbers were determined from root tip preparations of additional plants from open-pollinated seed produced on plants varying in regularity of meiosis (1944 Annual Report, page 38). A total of 887 plants have now been determined and,

of these, one had 26 chromosomes, 51 had 27, 44 had 29, 6 had 30, 2 had 31, and 6 had 42. In addition, seven plants had centric fragments that appeared to be approximately one-half as long as normal chromosomes.

Seed was obtained in the greenhouse from backcrosses of 35 chromosome plants to normal 28 chromosome plants and from this seed approximately 100 plants have been established in pots. The chromosome numbers of these plants will be determined from root tip preparations. Among the open-pollinated progeny of the hexaploid plant (1944 Annual Report, page 38), two plants were approximately octoploid. Tentative determinations from root tips indicate that these plants may have 53 and 54 chromosomes.

Colchicine Induced Autotetraploidy in *Festuca elatior* and *Dactylis aschersoniana*. The process of vegetative increase by single tiller isolation to obtain pure diploid and tetraploid clones of meadow fescue from chimeral plants produced by colchicine treatment (1944 Annual Report, page 40) was continued. Several pairs of diploid and tetraploid clones have been purified and are available for further cytogenetic studies. Some of the clones were susceptible to *Helminthosporium* net blotch and have been lost during greenhouse culture.

Some additional cases of chromosome doubling in *Dactylis aschersoniana* have been obtained and vegetative increases for purification of these clones are in progress. Three pairs of diploid and tetraploid clones obtained from previous treatments (1944 Annual Report, pages 40 and 41) are being induced to flower in the greenhouse. This material will be used for cytological analysis and for tests of cross-compatibility with normal *D. glomerata*.

A Diploid *Dactylis* spp. from Iran. Two lines of reasoning have suggested that diploid forms of *Dactylis* occur in southern Europe, the Mediterranean region or Asia Minor:

1. *D. glomerata* has morphological characters not found in *D. aschersoniana* and its range of distribution is to the south and at lower altitudes than *D. aschersoniana*.
2. Taxonomic descriptions of some southern European types suggest that these types may be diploid.

It has not yet been possible to obtain these southern European types for determination of chromosome number. Through the courtesy of Mr. M. A. Hein, five plants were obtained from a seed collection from Iran and

these plants proved to be diploid ($2n = 14$). Seed was obtained from these plants in the greenhouse in the spring of 1945 and some of this seed has been treated with colchicine for the induction of chromosome doubling.

Chromosome Numbers in *Bromus inermis*. Bromegrass has been reported to have chromosome races with $2n = 42$, 56 and 70. Because of the importance of difference in chromosome number among plants used in the breeding program, an attempt is being made to determine the chromosome number of each of the selected plants included in the polycross plot (page 42 of this report). A majority of the determinations have been made and, to date, all plants for which the count seems certain have been octoploid ($2n = 56$).

Origin of Natural Polyploids in *Festuca elatior*. The hybrids of diploid (meadow fescue) and hexaploid (tall fescue) types of *F. elatior* (1944 Annual Report, page 40) proved completely sterile in the greenhouse in 1944-45. Cytological analysis of microsporocytes has revealed a high frequency of bivalent and multivalent formation and low frequency of univalents, indicating considerable homology between chromosomes of the different genomes of the hexaploid. These results are consistent with the observation of quadrivalents at meiosis in the hexaploid and with the behavior observed in the F_1 of *Lolium perenne* x *F. elatior* ($2n = 42$).

PATHOLOGY

Disease Notes and Collections

The heavy snowfall of last winter and the unseasonably early warm weather of last spring resulted in some deviations from the normal pathological situation. There was extensive damage to many grasses due to development of snowmold (*Typhula* sp.). Collections of sclerotia were made on Kentucky bluegrass, bentgrasses, orchard grass, and perennial ryegrass. Several different species of *Typhula* were involved but positive identifications must await further examination of the material collected.

Considerable killing of forage legumes including red clover, Ladino clover, crimson clover and sweet clover was found as a result of infection by *Sclerotinia* sp. This was summarized in a published note following a disease survey in West Virginia (page 68 of this report). Apothecia of *Sclerotinia* were found in plots of Ladino clover and Kentucky bluegrass

where extensive damage was noted. In some plots, the stand of Ladino clover was only one-half that estimated the previous fall. At the time the apothecia were discovered, the weather had turned cold and damp following a prolonged early warm spell.

Leaf spot of Kentucky bluegrass caused by Helminthosporium vagans was extremely bad early in spring. Plots receiving liberal quantities of a nitrogen fertilizer and irrigated the previous summer and fall were particularly severely infected.

Alfalfa in most of Pennsylvania and other parts of the region was damaged by an unusually severe epidemic of black stem (Ascochyta imperfecta). Due to wet, cool weather late in the spring, farmers were unable to cut the first crop which then grew rank and lodged in many places thus establishing ideal conditions for rapid development of the pathogen. The tremendous build-up of inoculum on the stems of the first crop provided a source of infection for succeeding crops so that the pathogen remained present throughout most of the growing season. During the latter part of September, some alfalfa plants in the nursery at State College were found that were extensively infected with rust.

Leaf rust was found on Poa pratensis the last week in March which is far earlier than normal. Some leaf rust also was found on Agropyron repens but no stem rust was located on this or other grass hosts examined. During midsummer extensive infections of stem rust developed on timothy and orchard grass. A severe epiphytotic of crown rust developed on Lolium perenne and Festuca elatior during August. Even glumes and floral parts were covered by rust pustules.

Ergot was found extensively distributed on Agropyron repens and to a lesser extent on Lactylis glomerata. The disease was prevalent as usual on Bromus inermis.

Studies on Crown Rust (Puccinia coronata) of Festuca elatior and F. elatior var. arundinacea

Testing of collections in the greenhouse (1944 Annual Report, pages 55 and 56) was completed and the experimental data were summarized. The data corroborated earlier observations that Festuca elatior was generally susceptible to crown rust while F. elatior var. arundinacea was usually resistant. Of the many collections of F. elatior tested,

only the one from Maine was immune to rust. Additional material from the same field proved to be F. elatior var. arundinacea which varied in rust reaction from susceptible to immune.

Further cross-inoculation tests of crown rust on meadow fescue and perennial ryegrass were conducted. Preliminary tests indicated that the variety of rust that occurs on meadow fescue attacks perennial ryegrass with equal facility. More extensive tests are in progress.

Studies on Stagonospora Leaf Spot of Orchard Grass

Field Observations. For the first time in four years Stagonospora leaf spot was not abundant in the early spring. Instead, Rynchosporium orthosporum, a leaf spot of relatively minor and sporadic occurrence was dominant. This sudden change in prevalence of two diseases is attributed to the unusual weather conditions that characterized the spring of 1945.

Inoculation Experiments in the Greenhouse. The experiment on age and maturity of orchard grass clones in relation to sporulation of Stagonospora (1944 Annual Report, page 57) was completed. Results obtained showed that no sporulation resulted on any of the six susceptible clones tested at different stages of maturity up to and after heading. Inoculation of seedlings of eight lines of susceptible orchard grass gave abundant infection but no sporulation of the pathogen.

Since fruiting of Stagonospora could not be induced on Dactylis glomerata an attempt was made to inoculate Lactylis aschersoniana to determine (1) whether or not the organism would infect this host and (2) whether or not the organism could be induced to fruit on this host. Inasmuch as nothing was known regarding the susceptibility of this grass to Stagonospora 43 clonal lines were inoculated with spores from diseased orchard grass collected the previous summer. The diseased leaves of infected orchard grass were thoroughly macerated in a Waring blender in order to liberate the spores from the pycnidia. The spore suspension so obtained was atomized on leaves of the plants to be tested and the inoculated plants were incubated in a moist chamber for 48 hours before being placed on a greenhouse bench. Ten days following inoculation, there were abundant lesions on leaves of all inoculated plants. Most of the clones proved highly susceptible although a few were moderately resistant. None was highly resistant or immune.

After six weeks in the greenhouse, abundant pycnidia were found in the dead or dying leaves of some plants of Dactylis aschersoniana. Of the 43 lines inoculated only 13 failed to display evidence of fruiting of the organism. Microscopic examination of pycnidia from leaves of several plants revealed that they were mature and contained normal-appearing, germinable spores. The pycnidia appeared slightly smaller than those on Dactylis glomerata naturally infected under field conditions. This may have been due to the artificial conditions resulting from inoculating and growing the plants in the greenhouse. The identity and pathogenicity of the spores produced on Dactylis aschersoniana were confirmed by inoculating a susceptible clone of Dactylis glomerata on which typical lesions were produced.

Triplicate pots of more than 150 clones of orchard grass were inoculated in the greenhouse with composited inoculum of Stagonospora collected in the field. This was done to determine whether or not plants of varied infection type could be differentiated on the basis of size, shape, or color of lesions produced. No definite or constant differences other than size of lesion were obtained and this phase of the study, therefore, was abandoned.

Susceptible clones of orchard grass were inoculated with a spore suspension of Stagonospora and incubated at three different temperature levels--15° C., 21° C., and 30° C. Six days after inoculation, translucent lesions were appearing on leaves of inoculated plants incubated at 15° C. and 30° C. Spots on leaves of inoculated plants incubated at 21° C. were beyond the translucent incipient stage and had already begun to darken. After 15 days at the different temperatures, it was obvious that the best and most rapid development of lesions occurred on plants incubated at 21° C. Plants incubated at 15° C. had fairly well developed lesions but they were not so pronounced. Only a few poorly developed spots were visible on leaves of inoculated plants incubated at 30° C. No pycnidia developed on leaves of any of the inoculated plants.

Red Clover Observation Nursery

The nursery planted in the spring of 1944 with twelve strains of red clover was observed throughout the summer for prevalence of mildew, rust, and various leaf spot diseases. Notes were taken on October 22, 1945, for survival of stand following clipping and two summers' growth. Of the twelve strains tested two local Pennsylvania collections were outstanding with an estimated 75 percent of the stand surviving. Kentucky

southern selection survived quite well as did another Pennsylvania collection. In each of the other strains including Cumberland, Midland, Tennessee, Dollard and Ottawa 0 to 25 percent of the plants survived.

The nursery planted in the spring of 1945 was rated with respect to establishment of stand but disease notes will not be taken until next growing season.

Alfalfa Wilt

During the past year rather intensive investigations were initiated on some little known aspects of the wilt problem. Cultures of the pathogen were kindly contributed by other investigators and isolates were secured from locally collected diseased plants. In making isolations from diseased tissue the extremely slow-growing wilt bacteria were frequently completely inhibited by contaminating organisms. An effective technic for obtaining the wilt bacteria from diseased tissue was developed in which sections of diseased roots were immersed in 1:500 $HgCl_2$ in 50 percent ethyl alcohol for several (3 to 8) minutes. The surface sterilized root sections were then transferred aseptically to sterile Petri dishes where they were washed twice with sterile water. The outer bark of the root was then sliced away with a flamed scalpel and thin cross-sections of the underlying diseased woody tissue were sliced with the scalpel. The pieces of tissue were transferred aseptically to tubes of nutrient-dextrose broth and crushed with a flamed glass rod. The tubes were permitted to stand approximately one hour so that the bacteria could diffuse from the tissues. Nutrient-dextrose agar dilution plates were then prepared from this material.

During the course of such isolations, it was frequently observed that certain potent bacterial contaminants were able to inhibit completely growth of wilt bacteria within zones of 3 to 4 cm. around the contaminants. On the other hand, certain contaminants failed to affect visibly the growth of the wilt bacteria. One contaminant apparently stimulated growth of wilt bacteria in its vicinity. Several other contaminants stimulated rapid production of the blue pigment characteristic of colonies of the wilt organism on some culture media.

Pathogenicity of cultures was tested in the greenhouse on young alfalfa plants of the susceptible Grimm variety. Several modifications of published technics were tried. The most drastic involved growing the organism in flasks of nutrient-dextrose broth 10 to 15 days and using the broth as inoculum. Satisfactory infection was secured by this method and it was found that

effective inoculation could be expected to the extent of about 75 percent for a susceptible variety. Infected plants were killed in some cases as early as six weeks following inoculation. Some plants lived but were stunted and showed many of the symptoms characteristic of diseased plants growing in the field. Other inoculated plants appeared healthy and could not be positively diagnosed until the roots were examined and the characteristic yellow discoloration found.

During the course of inoculation experiments in 1945 some inconsistent results were obtained. This stimulated investigations to determine the effect of the following factors on infection of seedlings by wilt bacteria:

1. Effect of length of inoculation time on degree and severity of infection.
2. Age of plant at time of inoculation.
3. Effect of clipping plants periodically after inoculation.

These experiments are in progress but not all the data have been secured.

Several experiments designed to shorten the length of time necessary to determine susceptibility or resistance to the disease are under way. One of these involves inoculating cuttings from healthy susceptible alfalfa plants, then rooting the cuttings in flats filled with expanded mica sold under the trade name of "Vermiculite". In preliminary experiments, excellent rooting of cuttings and growth of seedlings took place in this material. It is advantageous because its moisture-holding capacity is about five times that of sand. It is loose and cannot pack and is almost completely devoid of organisms causing damping-off. Roots of seedlings growing in "Vermiculite" are white and clean in contrast to those of seedlings grown in sand or soil which frequently are discolored by soil microorganisms.

Another experimental short-cut involves inoculating seedlings a few days old with wilt cultures. Seeds are usually germinated in Petri dish moist chambers at a constant temperature for 48 to 72 hours. The tip of the primary root is then severed and the cut end is either dipped in a suspension of the wilt bacteria for one hour or smeared with bacteria from an agar slant culture. The severed inoculated seedlings as well as severed uninoculated seedlings are then placed in Petri dish moist chambers for incubation at 25° C. for five days. At the end of this period the seedlings that have produced new rootlets at or adjacent to the cut surface are

counted in comparison with the seedlings that have failed to produce new rootlets. Although this technic is still in a very preliminary stage of development, it appears promising enough to warrant further intensive investigation.

Viability Tests on Seeds of Alfalfa,
Red Clover, Ladino Clover, and Sudan Grass
Treated with Different Fungicides

This experiment, begun in 1943 (1944 Annual Report, page 56), was continued and periodic germination tests were made on the treated seeds in Petri dishes, flats of steamed soil, and flats of soil inoculated with Pythium spp. After 30 months, treated seeds of alfalfa, red clover, and Ladino clover stored at 25° C. showed no appreciable injury from any of the fungicides tested. There was no difference in germination between seeds stored in open and closed containers at 25° C. Germination of Sudan grass treated with New Improved Ceresan was noticeably reduced one month following treatment and within six months none of the treated seeds germinated regardless of storage temperature or conditions. None of the other fungicides injured germination of Sudan grass. At 10° C., germination of treated and untreated seeds of all species stored in closed containers was much better than germination of seeds stored in open containers.

Treated seeds sown in infested soil were protected against pre-emergence damping-off to some extent. Experiments are now in progress to determine whether the fungicides are still effective against soil-borne microorganisms.

Influence of Spergon on Germination
of Trifolium repens

Some further tests (1943 Annual Report, pages 59 to 61) were made of the fungicidal properties of "Spergon" in relation to germination of treated seeds of Trifolium repens. Three lots of Ladino clover seed and three of white clover were treated with different samples of the fungicide. The different seed lots showed different degrees of inhibition in germination when treated with Spergon. This may explain the discrepancy in results obtained at the Wisconsin Agricultural Experiment Station and the earlier results obtained at the Laboratory.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Photoperiodic Responses of Several Pasture Species

In previous studies (1942 Annual Report, pages 42 and 43, 1943 Annual Report, pages 42 to 44, and 1944 Annual Report, pages 43 to 45) it was shown that breaking the normal dark period with an hour of light during the middle of the night induced heading and flowering of orchard grass similar to that induced by increasing the winter day length to 16 hours. During the winter of 1944-45 preliminary studies were conducted to determine the responses of orchard grass, brome grass and Canada bluegrass to light intervals of 1/16, 1/8, 1/4, 1/2 and 2 hours duration (75 foot candle intensity) occurring during the middle of the normal winter night. The results of these trials indicated that breaking the normal dark period with intervals of light as short as 1/16 hour induced the formation of normal sized heads of orchard grass but growth habit became semi-prostrate and flowering occurred about two weeks later than in plants receiving a 16-hour day. Increasing the length of the light period from 1/16 hour to 1/8 hour and subsequently up to two hours hastened the flowering date. It is evident that short intervals of light during the middle of the normal winter night are effective in initiating reproduction responses of these grasses.

Vegetative Responses of Seven Grasses to
Supplementary Light

Trials were continued to determine the vegetative responses of seven grasses to length of light period and of dark period (1944 Annual Report, page 44). The plants were grown in the greenhouse during the shortest days of the winter. Mazda bulbs to provide supplemental light at an intensity of about 100 foot-candles were used to obtain various day lengths. Shorter dark periods were obtained by using lights for short periods during the middle of the night. The seven grasses used in these trials were orchard grass, timothy, brome grass, reed canary grass, tall oat grass, meadow fescue, and Kentucky bluegrass. In all species longer days resulted in much greater elongation of tops and except for Kentucky bluegrass the yields of tops increased slightly (about 10 percent) with increasing day length up to about 16 hours. The yields of tops were about the same under 16- and 18-hour days (18-hour days were the longest included in the trials). In Kentucky bluegrass the yields of tops were much lower under 16- or 18-hour days than under shorter days.

In orchard grass, reed canary grass, and meadow fescue the yields of roots were affected very little if any by increases in day length, but in the other four species the yields of roots decreased with increasing day length. The total yields of tops plus roots for all species were very nearly the same at day lengths of 9 to 10, 11, 12, 14, 16, or 18 hours.

In general the appearance of plants grown under natural day length (9 to 10 hours) but supplied with either 1/2 hour or 2 hours of light in the middle of the normal dark period was similar to that of plants grown under a 14-hour day. The total yield of dry matter, however, averaged slightly less than that of plants grown without supplementary light.

The Responses of *Dactylis glomerata*-*Trifolium repens* var. *latum* and *Bromus inermis*-*T. repens* var. *latum* to Ammonium Nitrate and to Height and Frequency of Cutting

Studies on the time and height of clipping orchard grass-Ladino clover and brome grass-Ladino clover as they relate to yield and persistence of the legume (1944 Annual Report, pages 46 to 49) were continued during 1945. A general summary of the effects of time of removal of the first crop in the spring and the response of the grass-legume associations to 60 pounds of nitrogen applied in early April 1945 is presented in Table 8. It is evident from these data, as well as those presented previously (1944 Annual Report, page 48), that by delaying the harvest of the first crop in the spring the total yield for the year is increased, but that the amount of Ladino clover in the association is decreased. In all cases, the application of 60 pounds of nitrogen per acre as ammonium nitrate increased the yield of grass and decreased the yield of legumes. This decrease in the legume was progressively greater as the harvest of the first crop was delayed later in the season. The addition of nitrogen did not increase the total yield of those plots harvested in the spring when the herbage was 10 to 12 inches high, but the yields of the plots cut later, at the early head stage and full bloom stage, were increased.

The data from the second year of clipping at several heights indicate that the yields are somewhat greater on plots cut to one inch than on plots cut to three inches and that the amount of Ladino clover in the association is also slightly greater on the plots clipped closer.

The differential recovery of orchard grass and brome grass during midsummer was less noticeable in 1945 than in 1944, perhaps due in part to more favorable rainfall in 1945.

While the total yields of brome grass for the season are greater than of orchard grass, particularly in the later spring cuttings, the largest part of that yield occurred in the first crop. This is further evident by the fact (Table 8) that in several cases one more cutting of orchard grass-Ladino clover could be made than of brome grass-Ladino clover.

The results from the second season substantiate those made the previous year: the time of removal of the first crop in the spring is a critical factor in determining the amount of Ladino clover in a grass association and particularly when nitrogen fertilizer is applied.

The Effects of Nitrogen Fertilization, Irrigation
and Clipping Treatments on the Yield and Botanical
Composition of a Poa pratensis-Trifolium repens sod

The first year's results in the study of the responses to nitrogen fertilization, irrigation, and clipping treatments were previously reported (1944 Annual Report, pages 49 and 50). Rainfall was generally favorable in 1945, although short periods of dry weather occurred between late June and early September. During this period a total of 5.4 inches of water was applied to the irrigated plots. This amount was believed sufficient to maintain adequate soil moisture for optimum growth throughout the season.

The clover population under different treatments is summarized in Table 9. In the absence of nitrogen fertilizer excellent stands of clover were maintained except on plots clipped from five inches to two inches. Even these plots contained good stands of clover. Heavy rates of nitrogen fertilizer materially decreased the stand of clover on non-irrigated plots. This decrease was most pronounced under the 2-inch clipping treatment, where clover was almost entirely eliminated. On the irrigated plots excellent stands of clover were maintained even with very high levels of nitrogen fertilization, particularly on the plots clipped to one-half inch or one inch. These high clover populations on the high nitrogen, irrigated plots are believed to be due to a number of interacting factors. In the first place clover is better able to compete with grasses on moist soils than on dry soils. Moreover, it appears that high nitrogen and abundant moisture throughout the summer of the preceding year lowered the reserves of the grasses even under the 2-inch clipping treatment. This lowering of carbohydrate reserves may have decreased the resistance of the grass to infestation of Helminthosporium leaf spot. The data also suggest that

Table 8. The effect of stage of growth and nitrogen on yield of orchard grass-Ladino clover and bromegrass-Ladino clover during 1945.

Clipping treatment	Pounds per acre oven-dry weight			
	Total number	Ladino cuttings	Grass	Total
Orchard grass - Good Ladino clover				
Approx. 10" to 2"	4	1728	3499	5227
Approx. 10" to 2" + N*	4	1233	3567	4800
Early head to 1", then 10" to 2"	4	1003	4274	5277
Early head to 1", then 10" to 2" + N	4	830	4826	5656
Late head to 1", then 10" to 2"	3	431	4597	4928
Late head to 1", then 10" to 2" + N	3	164	5662	5826
Orchard grass - Thin Ladino clover				
Approx. 10" to 2"	4	1321	3178	4499
Approx. 10" to 2" + N	4	766	3588	4354
Early head to 1", then 10" to 2"	4	1035	3987	5022
Early head to 1", then 10" to 2" + N	4	471	4713	5184
Late head to 1", then 10" to 2"	3	1016	4142	5158
Late head to 1", then 10" to 2" + N	3	203	5599	5802
Bromegrass - Ladino clover				
Approx. 10" to 2"	4	2988	2586	5574
Approx. 10" to 2" + N	4	2022	3496	5518
Early head to 1", then 10" to 2"	3	1607	3737	5344
Early head to 1", then 10" to 2" + N	3	1051	5505	6556
Late head to 1", then 10" to 2"	3	178	5934	6112
Late head to 1", then 10" to 2" + N	2	17	7353	7370

* 60 pounds of nitrogen per acre applied in ammonium nitrate in April 1945.

irrigation during the previous summer may have favored a build-up of disease inoculum, resulting in a heavy infestation of Helminthosporium leaf spot on the grass during late April and May of this year. The relatively poor growth of the diseased grass resulted in less competition to the clover. During the summer months Helminthosporium apparently was not a factor, yet, with optimum moisture, high clover populations were maintained regardless of the nitrogen level, particularly under the closer clipping treatments.

Table 9. The effects of nitrogen fertilization, irrigation, and clipping treatments on the clover population of a Kentucky bluegrass sod. Figures are the average of 2 to 5 estimates during July, August, and September.

Clipping treatment	: Estimated percentage stand of clover			
	: No nitrogen		: High nitrogen*	
	: Not		: Not	
	: irrigated:	Irrigated:	irrigated:	Irrigated
To 1/2" when 4"	: 57	: 52	: 28	: 48
To 1" when 4 to 5"	: 45	: 50	: 24	: 42
To 2" when 5"	: 36	: 33	: 1	: 32
To 1/2" when 3" in	: 54	: 55	: 20	: 60
early spring,	:	:	:	:
thereafter to 1"	:	:	:	:
when 4 to 5"	:	:	:	:
	:	:	:	:

* 40 pounds nitrogen per acre after each clipping.

The total yield of dry matter for the season ranged from 4083 pounds per acre for the plots clipped from five inches to two inches without nitrogen fertilization or irrigation to 8541 pounds for high nitrogen, irrigated plots clipped to one-half inch. The yield of all plots clipped to two inches averaged 5569 pounds as compared with 7810 for all plots clipped to one-half inch. The 1-inch clipping treatment gave intermediate yields (6771 pounds). The responses to nitrogen fertilizer were in general relatively small because of the high clover populations. By far the largest increase was obtained under the 2-inch clipping treatment without irrigation, where yields of 4083 and 6326 pounds, respectively, were obtained from no nitrogen and high nitrogen.

Irrigation greatly increased the yield during July and August but the total increase in yield for the season was small, particularly on the high-nitrogen plots. This is shown in Table 10 for the plots clipped to two inches. In the early spring (prior to April 9) the yields on the

irrigated and the nonirrigated plots were about the same, but during the latter part of April and May when the plots were heavily infested with Helminthosporium, the irrigated plots produced relatively poor growth. During the dry part of the summer irrigation more than doubled the yield of dry matter. Later in the fall, however, the irrigated plots were less productive than the nonirrigated plots. This decrease in the fall is attributed to low carbohydrate reserves.

Table 10. Seasonal distribution of yields of Kentucky bluegrass-white clover mixtures as affected by irrigation. (All plots received high nitrogen* and the herbage was clipped to 2" when 5".)

Season of year	Yield of dry matter, pounds per acre	
	Not	Irrigated
	irrigated	
Before April 9	548	547
April 9 to June 22 (June 19 at high nitrogen)	3441	2159
June 22 to September 13	1553	3403
September 13 to October 10	784	470
Total	6326	6579

* 40 pounds of nitrogen per acre after each clipping.

The Response of Various Forage Grasses and Legumes to Phosphate Fertilization

Last year in studies with seedlings in the greenhouse, grasses responded more to phosphate than did legumes (1944 Annual Report, page 51). Continued studies supported the earlier results.

This year phosphate responses under field conditions were obtained on a Dunmore silt loam on plots of pure species seeded without a companion crop in the early spring of 1944. All plots received lime and potash and the grasses received nitrogen fertilizer in the spring and again after cutting. Superphosphate at rates of 0, 80, and 200 pounds of P_2O_5 per acre was applied at the time of seeding. The eight species in the trial were alfalfa, red clover, Ladino clover, birdsfoot trefoil, orchard grass, brome grass, timothy, and tall oat grass. Orchard grass and Ladino were clipped three times this year; all other species were clipped twice. The dates of the first

cutting ranged from May 16 for orchard grass and Ladino clover to June 19 for alfalfa, birdsfoot trefoil, and brome grass. The yields of dry matter from the different phosphate levels are summarized in Table 11.

Table 11. Responses of forage grasses and legumes to phosphate fertilization on Dunmore silt loam.*

P ₂ O ₅ applied, pounds per acre	Yield of dry matter, pounds per acre			
	Average of		Average of orchard	
	alfalfa,		grass, brome grass,	
	Birdsfoot trefoil	Ladino clover, red clover	tall oat grass and timothy	
	First cutting			
0	2809	1739	3688	
80	3695	2687	4442	
200	3584	3233	4570	
	Subsequent cuttings			
0	1102	1393	1192	
80	997	1542	1467	
200	1024	1584	1652	
	Total			
0	3911	3132	4880	
80	4692	4229	5909	
200	4608	4817	6222	

* All plots received lime and potash and in addition the grasses received nitrogen.

In the first cutting, the legumes (except birdsfoot trefoil) responded much more to phosphate fertilization than did the grasses, but in subsequent cuttings the response was generally rather low in all species. Birdsfoot trefoil produced relatively good yields without phosphate and responded less to phosphate than the other legumes or even the grasses.

It is also of interest that in the first year after seeding, the yields of birdsfoot trefoil (seeded alone) were higher, even at the high phosphate levels, than were either alfalfa or Ladino clover. This substantiates earlier observations that one of the reasons for the slow rate of establishment of birdsfoot trefoil is that in the seedling stage it is very sensitive to competition from other species ordinarily sown in association with it.

Phosphate Placement Studies

Phosphate in bands, 14 inches apart and two inches below the surface of the soil, has been no more effective than phosphate broadcast and worked into the soil in tests with a seeding of orchard grass-Ladino clover on Dunmore silt loam. The phosphate was applied at rates of 50, 100, and 200 pounds of P_2O_5 per acre at the time of seeding in early spring of 1944. All plots received lime and potash.

Inhibitory Plant Growth Factors in Partially Sterilized Soils

The results of further studies of plant growth on partially sterilized soil (1944 Annual Report, page 51) indicate that no single factor is responsible for the poor growth that may be obtained with certain species of plants. In all cases, however, heavy applications of phosphate have resulted in very good growth. Various carriers of phosphate including manganoous phosphate, 20 percent superphosphate, mono-, di-, and tri-calcium phosphates, sodium glycerophosphate, mono-sodium phosphate, ferric phosphate, and mono- and di-ammonium phosphates have all been effective.

Effect of Depth of Planting on Bromegrass Establishment

The effects of depth of planting and of a companion crop on establishment of bromegrass have been under investigation for the past two seasons. Preliminary observations have indicated that depth of planting was an important factor in the establishment of this species. An experiment was set up in which several strains of bromegrass were planted in rows at depths ranging from 1/4 to 2 inches with and without a companion crop of oats.

At the shallower depths of 1/4, 1/2 and 1 inch, good stands of vigorous seedlings were obtained from all of the strains. Emergence was more difficult at the deeper depths of 1-1/2 and 2 inches. These plants were lacking in vigor and were slow in subsequent development. At the 2-inch depth a 57 percent reduction in the stand resulted when compared to the 1-inch depth. From the 1-inch to the 1-1/2-inch depth the stand reduction amounted to 27 percent. In general, the emergence of bromegrass may be considerably reduced when planted at depths greater than one inch.

A companion crop of oats seriously depressed top growth and tiller development of the seedlings. Only $1/4$ as many tillers were produced and $1/8$ as much dry weight of top growth was obtained from bromegrass seedlings grown in association with the oats as was obtained where a companion crop was not used.

Reserve Studies on Grasses

Chemical analyses of materials collected in various studies relating to reserve substances in grasses have been continued but are not complete.

When carbohydrates as well as total dry matter were depleted from ryegrass more rapidly at higher than at lower temperatures (1943 Annual Report, pages 52 and 53), nitrogen and ash were similarly lost from the stubble and roots but at a much less rapid rate than were the carbohydrates so that apparent increases in the former were sometimes observed. Percentages of total nitrogen increased at all temperatures during the early half of a 40-day experiment when the depletion of the carbohydrates was most rapid. Thereafter the increases took place in the stubble and roots only at the higher temperatures. In newly formed leaves the percentage of protein nitrogen increased during the early part of the 40-day period but decreased in the latter part more rapidly at the lower temperatures. Soluble nitrogen increased at all temperatures in the stubble but the rate was so rapid at the higher temperatures that the stubble at 80 to 90° finally contained almost four times as much soluble nitrogen as that at 50 to 60°. The roots were comparatively unaffected by temperature as regards percentages of soluble nitrogen. Nitrates were lacking at all times. The total ash percentage was similarly greater at higher temperatures in the stubble but not in the roots.

In an aftermath experiment with orchard grass (1944 Annual Report, pages 52 and 53) protein nitrogen was consistently higher in grass grown under high rather than under low nitrogen in all parts of the plant and at all periods of collection. In a hay and aftermath experiment (1944 Annual Report, pages 53 and 54) the highest percentage of protein nitrogen was obtained in the 35-day old aftermath when nitrogen was added at the latest date, namely, 14 days after cutting for hay. The highest yield of protein per pot was found however in the highest yielding series, namely, when nitrogen was applied on the day of cutting for hay. Similar data have been obtained with the stubble and roots and with hay. Some data are presented in Table 12.

The Comparative Chemical Composition of Different Species

Grass plots were established for the purpose of comparing the composition of different species growing under the same environmental conditions. All plots were in triplicate and randomized. Because of the wartime labor shortage and for other reasons these plots were abandoned after a few samples had been collected. Some comparisons have been made.

Of 10 common species cut in the spring (May 8 to 11), the highest crude protein was found in reed canary grass, namely, 22.1, 22.4, and 22.8 percent. Commercial orchard grass contained 20.1, 21.0, and 21.6, seven other species were between 17.1 and 20.0 with no significant differences among them, and timothy was lowest with 12.6, 15.8 and 15.8 percent. Five orchard grass clones sampled at the same time showed no statistical differences in crude protein, the different plots ranging, with one exception, between 20.9 and 24.6 percent. In samples taken in July and September of the previous year of eight orchard grass clones, no obvious differences have yet been found in the protein or sugar contents.

SUMMARY

COOPERATIVE ACTIVITY

During 1945 a conference was held at the Laboratory to consider the problem of maintaining Ladino clover seed stocks. Plans were developed to have clones of Ladino clover tested both in the Northeastern Region and elsewhere and to have the better clones from such tests serve as foundation material for seed production.

Brief progress reports of the cooperative research projects active during the year may be found beginning on page 3. The breeding and further testing of promising new strains of forage grasses and legumes were continued. The pasture renovation experiments have provided basic information on how depleted pasture land may be made productive again.

RESEARCH AT THE LABORATORY

Cytogenetics and Breeding

One type of male sterility in orchard grass was found to be dependent for expression upon interaction of the appropriate cytoplasm with a dominant gene. Studies on the effects of inbreeding upon fertility in orchard grass were continued.

Inbreeding for the establishment of inbred lines was continued in orchard grass and in white clover. In orchard grass, a planting was made to provide material for study of the effects of inbreeding on combining ability. Plots were established for studying the correlation of clonal responses with polycross progeny tests of selected clones of orchard grass, Ladino and white clover. Other plots were established for studies of the different responses of varieties of orchard grass and alfalfa to systems of management and associated species. Variety trials of Kentucky bluegrass, with particular emphasis on interactions of varieties with clipping treatment and nitrogen fertilization, were continued. Plots were established for testing the behavior of pure varieties of Kentucky bluegrass compared with varietal mixtures.

Genetic investigations dealt with inheritance of several young plant characters and a few adult plant characters in orchard grass and with inheritance of size differences and leaf marking types in Ladino and white clover.

Chromosome numbers of a total of 887 plants of orchard grass have been determined in the study of effects of meiotic irregularities on aneuploidy. Six of these plants were hexaploid, one had 26 chromosomes, 51 had 27, 44 had 29, six had 30, and two had 31. Studies of the autotetraploids of Festuca elatior and Lactylis aschersoniana were continued. A diploid Lactylis sp. from Iran has been included in studies of the origin of L. glomerata. All plants of Bromus inermis examined to date have 56 chromosomes.

Pathology

Weather conditions in early spring favored development of several diseases usually evident but not abundant. Diseases more prevalent than usual were snowmold (Typhula sp.) and rusts of grasses: crown rot of forage legumes (Sclerotinia sp.) and black stem of alfalfa (Ascochyta imperfecta).

Further field and greenhouse tests with a rust immune strain of meadow fescue demonstrated its immunity to local collections of crown rust. Inoculation experiments with Stagonospora leaf spot of Lactylis glomerata revealed that stage of maturity of the host had no effect on fruiting of the organism under greenhouse conditions. When clones of Lactylis aschersoniana were inoculated, however, fruiting structures and viable spores were produced on infected leaves six weeks after inoculation.

Several technics are being investigated on inoculating bacterial wilt in alfalfa, some of which give promise of shortening the time required to distinguish between

susceptible and resistant plants. In the red clover disease observation nursery, several Pennsylvania selections were superior to commercial varieties with respect to survival of stand.

There was no appreciable injury to seeds of alfalfa, red clover, and Ladino clover treated with different fungicides and stored for 30 months at room temperature. Seeds stored in closed containers at 10° C. germinated better than those stored in open containers. Greenhouse tests revealed that different seed lots of Trifolium repens varied in degree of inhibition of germination when treated with Spergon.

Physiology and Composition

Photoperiodic responses of orchard grass, Canada bluegrass and brome grass in relation to heading and flowering in the greenhouse during the winter months indicate that these species produce heads when the normal winter night of about 14 hours is interrupted with short intervals of supplementary illumination during the middle of the normal dark period. As the interval of supplementary light is decreased from one hour to 1/16 hour the time of flowering is delayed.

Vegetative responses to length of light period and of dark period were determined for several species of grasses. In general, longer days resulted in greater elongation of tops, but the increases in yields of tops were relatively small. In most species, long days decreased the root-top ratio.

Management studies in the field on the effect of time and height of cutting orchard grass-Ladino clover and brome grass-Ladino clover associations with and without a spring application of nitrogen fertilizer have substantiated the previous year's results. Removal of the first crop in the early head stage of the grasses permitted the maintenance of a good stand of Ladino clover but later removal of the first crop reduced the amount of Ladino clover especially where a spring application of nitrogen had been made. Brome grass offered more severe competition than orchard grass to Ladino clover when the harvest of the first crop was delayed until flowering of the grass occurred. Removal of the first crop prior to heading increased the amount of Ladino clover in the associations but decreased slightly the total seasonal yields.

Studies on a Kentucky bluegrass-white clover sod emphasize the importance of height and frequency of defoliation and of soil moisture in determining the white clover stand, especially where nitrogen fertilizer is applied. The data indicate that where nitrogen fertilizer decreases clover, the decrease is an indirect effect resulting from increased competition from the grass. Irrigation to maintain favorable soil moisture together with clipping treatments that lowered the carbohydrate reserves of the grass resulted in excellent stands of clover even on plots that received a total of 360 pounds per acre of nitrogen fertilizer per year.

The response to phosphate fertilization of eight forage species (alfalfa, red clover, Ladino clover, birdsfoot trefoil, orchard grass, brome grass, timothy, and tall oat grass) was determined in the greenhouse and in the field. In the greenhouse seedlings of grasses responded more to phosphate than did legumes. In field plots legumes, except birdsfoot trefoil, showed large increases in yield in the first cutting from phosphate fertilization, but the increases in subsequent cuttings were small. Grasses showed moderate increases throughout the season.

In preliminary trials on Dunmore silt loam, band placement of phosphate fertilizer for orchard grass-Ladino clover was no more effective than phosphate worked into the soil by surface tillage.

Studies on the depth of seeding of brome grass with and without a companion crop of oats indicated that seeding at depths greater than one inch materially reduced the stands. The use of a companion crop of oats, even though it was removed prior to flowering, greatly decreased the size and weight of the brome grass seedlings--the dry weights of the plants grown without a companion crop were about eight times those of plants grown with oats.

Chemical analyses of materials collected in various studies relating to reserve substances in grasses have been continued. Ryegrass grown at high temperatures lost protein less rapidly than carbohydrates so that percentages of protein and especially soluble nitrogen increased. In orchard grass the highest protein but not the greatest yield of protein was found in the aftermath when fertilization was at a relatively late period. Some fragmentary data on the comparative composition of species are reported.

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MANUSCRIPTS PENDING

Atwood, S. S., and Kreitlow, K. V. Studies of a genetic disease of Trifolium repens simulating a virosis.

Myers, W. M. Cytology and genetics of forage grasses.

Appendix

(The responsibility for compiling each state report was assumed by the collaborator of that state)

PROGRESS REPORTS OF STATE STATIONS

STORRS (CONNECTICUT) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments.

Leaders: B. A. Brown and R. I. Munsell.

a. Response to Soil Treatments. The permanent plots, seeded in 1941, were continued in 1945. Systematic notes on stands, deficiencies and growth, as well as the dry-matter yields of the two cuttings were recorded for each of the 80 plots.

1. The question of how and when to apply potash for alfalfa has been studied in this experiment. Disking in the three years' supply (360 pounds of K_2O per acre) before seeding resulted in marked "luxury consumption" the first season and in a deficiency the third season. From the first to the sixth cutting the Ca/K ratio increased from 0.50 to 2.11. The corresponding ratios for alfalfa with annual potash applications were 0.87 and 1.43. Although the Ca and K contents of alfalfa fluctuated widely under the different methods of applying potash, the milliequivalents of three cations (Ca, Mg and K) totaled approximately the same in all cases.

The heavy infrequent treatments also had poorer stands in the third year than where the same total amount of K_2O was divided into annual or more frequent treatments. There appeared to be little benefit from dividing the annual quota of K_2O into two or three applications.

2. Although these plots had received limestone at 7-1/2 or 9 tons per acre between 1914 and 1929 and the reaction of the soil was about 6.0 in 1941, another ton per acre of limestone in 1941 increased the stands 14 percent and the yields 16 percent in 1945.

c. Effects of Amount and Depth of Applying Limestone. In this project, the stands of alfalfa, seeded in 1941, had become well mixed with volunteer grasses. Again, the stands and yields on plots with three tons of limestone in 1933 and none since were as good or better than where smaller amounts were applied in 1933 and repeated in 1941.

D. The Role of Minor Elements in Fertilizing Alfalfa. In 1945, the seventh year since applying borax at 20 pounds per acre, very little B deficiency occurred on the borax plots, while without borax 24 percent of the alfalfa showed distinct symptoms. Manure at 10 tons annually reduced the prevalence of deficient alfalfa to 5 percent, but did not increase its B content. Borax plots which had received additional limestone produced alfalfa with somewhat less B, especially in the second cutting. Adding more borax since 1938, increased the B content of the alfalfa 11 percent in the first cutting and 26 percent in the second.

In the six harvest years since 1938, the 30,000 pounds of dry matter from the borax plots have contained 1.1 pounds of B, an amount equal to half of that applied in the 20 pounds of borax. Because of the borax applied in 1938, 15 p.p.m. or 0.45 pounds more B were removed in the hay. This additional B removed represents about 20 percent of that added in the 20 pounds of borax.

In regard to manganese two facts stand out:

1. Legumes contain much less Mn than grasses.
2. Liming acid soils greatly reduces the absorption of Mn by plants. Examples of these statements are furnished by our analyses of pasture grasses and alfalfa. Liming permanent pastures reduced the Mn from 330 to 200 p.p.m.; more lime on alfalfa caused a reduction from 27 to 20 p.p.m. Adding Mn SO₄ to the soil had no apparent effect on the chemical analyses of alfalfa.

No effects have been noted from adding Cu and Zn in 1941 to plots of alfalfa.

Title: The Maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

a. The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. The precipitation was much more adequate in 1945 than in 1943 and 1944. As a result, the average production of digestible nutrients from 17 plots as measured by grazing with Holstein heifers from the same herds was 60 percent greater in the past season than the average of the two previous years. The "optimum mineral" plot (LPK annually), which had much more clover than any other pasture, responded most to the better moisture conditions. With 1838 pounds of TDN per acre it had the highest yield of any plot in 1945. The heifers grazing on this excellent white

clover-bluegrass pasture made large gains, had a very sleek appearance, but craved something else so much they broke a good fence reaching for brush on the other side. If this behavior was caused by a lack of fibrous roughage or some minor elements, or for other reasons, has yet to be determined.

The plot which was disked and seeded to Ladino in 1943 yielded fourth highest of the seventeen pastures, but, in spite of the more favorable season, the seeded clover did not occupy much of the area (3.6 percent in June). Kentucky bluegrass was again the dominant species.

In June considerable trefoil was found on the pasture where it was seeded without tillage in 1943. This was the first season any was seen there.

c. The Effects of Various Chemicals on the Soil, on the Botanical Composition of the Sward, and on the Stands and Growth of Kentucky Bluegrass and Rhode Island Bentgrass.
No new data were obtained in 1945.

d. The Adaptability of Varieties and Species of Grasses and Clovers for Pastures.

1. The Buffalo variety of alfalfa continues to be outstanding. Its average stand in 1945, the fourth harvest year, was 89 percent, a decrease of only 3 percent from 1944. In contrast, Grimm and Ontario Variegated had only 35 and 37 percent stands in 1945, or respective reductions from 1944 of 44 and 51 percent. The total yield of dry matter of Buffalo was 26 percent higher than the old varieties and the dry matter of Buffalo was nearly pure alfalfa.

The Ranger variety was second to Buffalo in both stand and yield. In both respects, Hardistan was third; although this variety is seriously affected by leaf spot in wet seasons, it has been resistant enough to wilt to maintain fair stands through the dry summers of recent years.

2. Management studies have been conducted for six complete harvest years on two Ladino-grass mixtures. Without exception, the ten systems yielded appreciably more dry matter in 1945 than in any previous year. Again the 6 to 2, 8 to 2, and 10 to 2 inch cuttings produced more dry matter than the comparable 6 to 4, 8 to 4, and 10 to 4 inch systems. There were only slight increases in yields with increasing heights when cut. In the case of the timothy-Ladino seeding, delaying the first cutting of the season to June 15 has resulted in the largest yields of dry matter, but it is impractical to cut

orchard grass mixtures so late because of the early maturity of that grass. To maintain any timothy in the stand, it is necessary to delay the first cutting until at least June 15. In spite of the fact that there has been very little timothy on these plots the 6-year average yields of six identical cutting systems were respectively 39 and 40 cwts. per acre for timothy-Ladino and orchard grass-Ladino seedings. There has been much more volunteer Kentucky bluegrass on the timothy than on the orchard grass section.

The stands of Ladino were good for all cutting systems in 1945. On June 21, the field appeared to be almost entirely Ladino. As in former years, cutting four inches above ground favored the grasses more than cutting to two inches. There appears to have been no benefit to stands of Ladino from not harvesting after September 1 or October 1, and yields have been reduced by those curtailments of the season.

In spite of the greater prevalence of Kentucky bluegrass on the timothy section, there was somewhat more Ladino there in 1945 than on the orchard grass area.

3. Crops for fall pasture: it cannot be emphasized too much that, in this region, September and October are the most difficult months during which to supply ample pasture. Legumes grow very much more slowly with the advent of cool weather and even with ample moisture large acreages of perennial grasses are required to provide much feed in that period. Moreover, grazing third-cutting alfalfa in September and early October will seriously thin the stand. Thus, species which will grow rapidly during the cool, short days of the early fall period may be very important in rounding out the potential grazing season.

Barley and oats were seeded about August 1 in both 1944 and 1945. Rates of seeding, cutting systems and amounts of N were the chief factors under test.

The precipitations of the two seasons were markedly different; 1944 was very dry until September 12, and then very wet, while 1945 was moderately dry in September and October.

Oats cut once, nearly three months after seeding, yielded slightly more than barley in 1944. The average of each species was nearly 2600 pounds of dry matter per acre. When cut on September 6, 1945, barley produced slightly more dry matter than oats, and considerably more than oats on September 27. Although the oats "rust" much worse than the

barley, it yielded about 30 percent more dry matter when the plots cut September 6 were mowed again on September 27. The totals were practically the same.

It was stated in the 1944 report that the heavier the seeding rate, the poorer the recovery of barley after cutting in the leafy stage. In 1945, this was true again for barley and also for oats. Table No. 13 clearly illustrates these statements.

Table 13. Ratios of first to second cutting yields of dry matter.

Seeding rates, bushels per acre	:	Barley	:	Oats
1.5)	:	0.92:1	:	-
3.0) 1944	:	1.77:1	:	-
4.5)	:	2.95:1	:	-
2.0)	:	1.23:1	:	0.67:1
3.0) 1945	:	2.61:1	:	1.27:1

Liberal use of a nitrogen fertilizer did not affect these ratios appreciably. It was noted that many plants did not grow at all after the first cutting and the proportion of such dead plants increased markedly with rate of seeding.

In 1944, yields of dry matter from barley were not affected by increasing the applications of N from 40 to 80 or 120 pounds per acre. Where September 6 and September 27 cuts were made in 1945, neither first-nor second-cutting yields of barley were affected by 80 instead of 40 pounds of N before seeding or by repeating the 40-pound application after the first cutting. Oats, under the same cutting systems, yielded slightly more on both dates when more than 40 pounds of N were applied.

When either barley or oats was harvested only once (September 27), slightly higher yields were obtained from 80 than from 40 pounds of N.

Since writing the 1944 report, the N content of the barley dry matter of 1944 has been determined. In the first cuttings, age was the most effective factor. Thus, for three rates of N and three rates of seeding, the decreases between September 19 and 29 averaged 21 percent; between September 19 and October 17, 42 percent. Rate of fertilizer N was also quite important. For both the September 19 and

29 cuttings, the differences between 40 and 80 pounds of N were about 20 percent, but between 80 and 120 pounds no appreciable differences occurred. About the same relationships existed in the second harvests of the plots cut first on September 19. On the other hand, older barley, cut on October 17 (80 days after seeding), increased in N content about 15 percent for each 40 pounds increment of fertilizer N.

Heavier seeding tended to decrease the percentages of N in the dry matter. This was consistently so of the first harvest (September 19), but became much less important with the passage of time, there being practically no differences in the October 17 cuttings.

4. Sudan grass: in 1945, three varieties were tested with both 40 and 80 pounds of fertilizer N. The dry-matter yields were practically the same for both rates of N. The "Common" variety reached greater maturity by September 5 and produced 3900 pounds of dry matter. On the same date the yield of "Tift" was also 3900 pounds, while that of "Sweet" was over 400 pounds less.

f. Causes of Fluctuations in the Prevalence of White Clover.
A Ladino-orchard grass seeding has been under twenty-four different fertilizer treatments since 1941. Four cuttings were made each year. There was little clover on any of the plots in 1944. In the early spring of 1945, the field was disked to retard the grass and Ladino reseeded at three pounds per acre. A remarkable increase in the area occupied by Ladino had occurred by mid-June and careful inspection indicated that about half of it was from the new seeding, the other half from a very rapid spread of old plants. On July 18, the least Ladino (28 percent) was on the no-potash plots, the most (73 percent) under P K B Cu Zn treatment. However, practically the same amounts of Ladino were found where no minor elements (B Mn Cu Zn) had been applied. Where one of the major mineral elements was not deficient, the chief reason for the generally greater prevalence of clover in 1945 than in 1944 appeared to be the much more favorable weather, particularly the amounts and distribution of the precipitation.

DELAWARE AGRICULTURAL EXPERIMENT STATION

Title: Pasture Management and Milk Production.

Leaders: C. E. Phillips, T. A. Baker and A. E. Tomhave.

Ample rainfall in 1945 was responsible for the longest grazing period, 165 days in the five years this experiment has been conducted. However, the same factor was probably responsible for

a leveling out of grass production on the different paddocks. The Ladino clover paddock produced the largest amount per acre but for the first time all other paddocks produced almost as well.

The production of the cows on pasture alone was about 72 percent as much as the cows on pasture plus grain.

It is calculated that the cows on pasture consumed about 90 pounds of green grass per day as an average for the season.

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Grassland Studies.

Leader: C. H. Moran.

The grassland studies involving top-dressed native pastures and Ladino clover-grass associations were continued at High-moor Farm. A herd of 20 milking cows and 10 young stocks were used to obtain the values listed in Table 14. The formula of Knott, Hodgson and Ellington was used to convert the milk production and weight gains to pounds of 4 percent fat-corrected milk per acre.

The comparison of spring and fall top-dressing on paddocks Nos. 2 and 3 clearly indicates that the returns from fall top-dressing are equivalent to those from spring fertilization. The fall top-dressing was applied annually between September 15 and October 15. Paddocks 10A and 10B were torn up and reseeded in 1943. The pastures were then at the height of production, but the experiment was tried to determine the effect on the new seeding. The addition of nitrogen at two levels, 50 pounds and 100 pounds per acre, to mineral fertilizers on paddocks 7A and 7B gave an average increase of 1086 pounds of milk per acre.

Title: Carotene Content of Grasses and Legumes.

Leaders: B. E. Plummer and C. H. Moran.

A study is being made of the carotene content and other nutrient values of many grasses and legumes at various stages of maturity. Table No. 15 reports some of the samples analyzed during 1944. A further report of grasses and clover analyzed during 1945 is now being prepared and will be published.

Table 14. Milk yields and gains as affected by top-dressing pastures.

Tons : Fertilizer : Yield		
Paddock: manure : pounds per acre : pounds of 4 percent milk per acre		
No.	per acre:	Nitrogen: P2O5 : K2O : 1941 : 1942 : 1943 : 1944 : 1945 : Average
Native pasture		
6A	- : - : 100 : 100	: 5175 : 4375 : 4040 : 3547 : 5802 : 4588
7A	- : 100 : 100 : 100	: 5450 : 7950 : 5890 : 3300 : 5712 : 5660
9A	10 : - : 60 : -	: 6525 : 5725 : 4632 : 3420 : 6406 : 5342
Ladino-timothy		
10A	10 : - : 60 : -	: 3625 : 6725 : 2902* : 4142 : 7267 : 5340
Native pasture		
6B	- : - : 50 : 50	: 4925 : 3950 : 4407 : 1921 : 3775 : 3796
7B	- : 50 : 50 : 50	: 5675 : 4900 : 4325 : 3845 : 5737 : 4896
9B	5 : - : 30 : -	: 6775 : 5300 : 4967 : 4107 : 6445 : 5519
Ladino-timothy		
10B	5 : - : 30 : -	: 3700 : 5800 : 2920* : 3757 : 6702 : 4990
Native pasture		
2**	- : 60 : 60 : 60	: 4425 : 3900 : 3045 : 3490 : 3892 : 3750
3***	- : 60 : 60 : 60	: 3875 : 4050 : 3255 : 2491 : 4580 : 3650

* 10A and 10B only half season of grazing and not included in the average.

** Fertilizer spring applied.

*** Fertilizer fall applied.

Large losses in carotene may occur in the natural curing of hay. Analyses of samples of hay cured under unfavorable weather conditions indicate that nearly all of the carotene was lost. In order to determine what these losses would be when samples were artificially dried, the content was determined before and after dehydration as shown in Table No. 16. Fresh Ladino clover was found to have a very high carotene content but a large percentage was lost during dehydration. Medium red and alsike clovers contained less carotene in the fresh material but lost a lower percentage on drying.

Title: Second Cutting Ladino Clover-Timothy as a Substitute for Alfalfa Leaf Meal.

Leaders: J. Robert Smyth, B. E. Plummer and C. H. Moran.

During the past three years, experiments have been under way to test the value of Maine-grown Ladino clover prepared by different methods as substitutes for alfalfa leaf meal in the poultry rations. Second crop Ladino clover-timothy as sun cured or dehydrated, ground hay, or as silage has been compared with alfalfa leaf meal. The silage was put up in 50-gallon molasses barrels and kept with very little loss from spoilage. The material retained a large part of its original high carotene content.

The tests have indicated that dehydrated Ladino clover meal compared favorably in all respects with dehydrated alfalfa leaf meal. Second crop Ladino clover-timothy hay, meal or silage is a satisfactory substitute for alfalfa leaf meal in laying rations.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: A Study of the Responses of Different Hay and Pasture Seeding Mixtures to Nitrogen Fertilization.

Leader: W. G. Colby.

A description of the experimental plan is given in the 1943 Annual Report, pages 82 to 84.

Rate and Time of Application. Further modifications in the experimental plan were made in 1945 in both rates of nitrogen fertilization and in time of fertilizer application. The results for 1943 and 1944 had shown that nitrogen applied in the early spring increased herbage yields only for the first grazing period in late May and early June. Since this is usually the time of peak

Table 15. Comparative feeding value of dehydrated clovers and grasses.

Crop	Number of samples	Moisture percent	Carotene p.p.m.	:1,000 units:		Percent	
				vitamin A	per pound	Protein: Fiber	Fat
Ladino clover	7	6.6	238	180	22.6	16.3	3.9
Medium red clover	4	6.4	216	164	16.7	23.6	3.1
Alsike clover	2	5.3	205	154	21.2	21.2	2.9
Lawn clippings	1	8.9	417	315	17.8	17.8	4.6

Table 16. Loss of carotene content during dehydration of clovers harvested in 1944.

Crop	Number of samples	Date cut	Carotene in p.p.m.:		Percent loss
			Fresh	Dehydrated	
Ladino clover	8	June 28-July 5	442	242	46
Medium red clover	3	July 10-27	277	219	21
Alsike clover	1	July 27	266	230	14

production anyway, further increases in yield are of comparatively little use, at least for grazing purposes. For this reason, the early spring nitrogen application on the pasture series was omitted. An early spring application was continued with the hay-pasture series and excellent increases in hay yields were obtained. Timothy gave the greatest response, followed in turn by redtop, tall fescue, orchard grass, smooth brome grass and meadow fescue.

A second and also a third application of 30 pounds of nitrogen were made in July and August on both series of plots. The observation had been made in 1944 that midseason applications of nitrogen tended to maintain the productiveness of hot weather tolerant grasses such as smooth brome grass, orchard grass, and meadow fescue. Since most of the growth response to nitrogen is represented in the first harvest following its application, two midsummer applications were made instead of one. The results in 1945 were not outstanding due to the abnormally wet season, but in general they followed the same trend as in 1944.

Title: Strain Trials with Grasses.

Leader: W. G. Colby

Performance of Orchard Grass Strains in Hay and Pasture Seeding Mixtures. Commercial strains of orchard grass and all improved strains of similar maturity such as Brage and Scandia II have not given promising results in either Ladino clover or Ladino clover-alfalfa mixtures. Even though grazing management is carefully controlled, commercial orchard grass will crowd out most of the Ladino clover by the end of the third grazing season--given normal weather conditions. In hay mixtures with alfalfa, the spread between the early maturing alfalfa is so wide that early cutting for hay injures the alfalfa and late cutting gives poor quality hay.

Late maturing strains such as S26 and S37 orchard grass are much more satisfactory from the standpoint of maintaining a satisfactory grass-legume proportion in the mixture and also in having maturity dates which coincide with that of alfalfa but both strains are not sufficiently winter hardy to be depended upon in Massachusetts. S143 orchard grass has given fair results with Ladino clover for pasture but it is even more susceptible to winter injury than either S26 or S37.

The most promising strain of orchard grass thus far tested is one which we have called Late Finnish Hay. It is intermediate in its growth habit, between the tall-growing stemmy commercial strains and the low-growing leafy Aberystwyth strains. Although it is in the same maturity class as the three English strains, it is definitely more winter hardy. It has given good results so far in plot trials both as a pasture grass with Ladino clover and as a hay grass with Ladino clover and alfalfa.

Performance of "Northern" and "Southern" Strains of Smooth Bromegrass. A seeding of 21 strains of smooth bromegrass from a wide variety of sources was made in the summer of 1944. Observations in 1945 tended to confirm those made earlier that "southern" strains are much more aggressive in their growth habits than "northern" strains and may provide stronger competition for Ladino clover than is desirable. During wet seasons such as was experienced in 1945, this is not an important consideration. Ladino clover will compete successfully with all strains but during dry seasons when grazing is short, such may not be the case. The aggressive southern strains in dry seasons may compete so successfully with the clover as to practically eliminate it from the mixture. When this occurs, nitrogen starvation occurs and productivity drops to a low level. When bromegrass is used in combination with alfalfa for hay, "strain" is not important.

Effect of Seasonal Weather Conditions on the Performance of Different Strains and Species. The very important influence of seasonal weather conditions on the performance of different grasses and legumes was effectively demonstrated during 1945. The whole growing season was abnormally wet. The growth response of the legumes and of Ladino clover in particular was greater than with any of the grasses. The result was that in plots where Ladino clover had practically been eliminated, such as in the tall fescue-Ladino clover and commercial orchard grass-Ladino clover mixtures, Ladino came back during the growing season and by fall made up an estimated 20 percent of the herbage. In the redtop-Ladino clover plot, the mixture was predominantly grass in 1944. By the end of 1945 it was predominantly clover. Ladino clover established itself even on a plot of a thick stand of pure Kentucky bluegrass.

Title: Poultry Range Seeding Mixtures.

Leader: W. G. Colby.

There has been a demand on the part of some poultrymen for a poultry range seeding mixture which could be seeded annually. They want a pasture that can be ranged from early spring through midsummer and then, for reasons of sanitation, be plowed and reseeded. This calls for a mixture of suitable

species which are winter annuals at least. Winter rye has been used but its period of usefulness in the spring is short. The use of field brome grass (Bromus arvensis) was suggested and in the fall of 1944 a cooperative trial with a commercial poultryman was established. The results in 1945 were very encouraging. This grass developed a thick, heavy turf which made early ranging possible and a good ground cover was maintained until past midsummer even though the area was stocked heavily. The grass seemed to be reasonably palatable. More extensive seedings were made in the fall of 1945. Another brome grass which may have possibilities is also being tried. This is rescue grass (Bromus catharticus). Winter hardiness tests were seeded in 1945 and if this grass proves to be winter hardy, it will be tried out under range conditions.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: Producing the Full Roughage Requirements on New Hampshire Dairy Farms.

Leaders: Ford S. Prince and Paul T. Blood.

This project is being conducted on outlying dairy farms. During 1945, plots on seven farms were harvested while on three farms progress was made in getting the pastures from a plot to a field scale. One or two additional farms will be added in 1946, on which separate fields will be seeded to one of the large grasses with Ladino clover.

In a 3-year summary (presented below) covering the data for six grasses from all the plots which have been harvested, smooth brome grass leads in total pounds of forage produced, while timothy is last.

<u>Grass</u>	<u>Pasture years</u>	<u>Oven-dry material per acre</u>
Smooth brome grass	12	5615
Orchard grass	18	5358
Tall fescue	11	5326
Perennial ryegrass	12	4978
Reed canary grass	10	4948
Timothy	15	4810

The column "Pasture years" is the sum of the number of the plots harvested for a whole season for the 3-year period. The plots were originally seeded to one of the grasses named with Ladino clover. The harvests represent either

this mixture, or just the pure grass in cases in which Ladino was winterkilled or reduced by overgrazing, or the grass with Ladino and any other grasses such as Kentucky bluegrass or bentgrass which may have volunteered into the stand.

In regard to seasonal distribution of forage produced, smooth brome grass has given the highest early yields, with tall fescue producing much higher autumn yields than any other grass.

Comparisons between complex seeding mixtures including Ladino and one of the large grasses with Ladino are available on two farms. In each case the pastures were seeded in 1942. The 1945 harvests show a 1400-pound difference in dry matter in favor of the simple mixture with Ladino. This superiority, we believe, is due principally to the greater freedom which Ladino enjoys in the simple mixtures by not having so much competition with redtop and other sward-forming grasses.

Two rates of seeding tests with orchard grass indicate that good stands and satisfactory yields may be secured on carefully prepared land with as little as three pounds of seed per acre, although heavier seeding rates up to 10 pounds have given slightly higher yields of dry matter.

Title: Seed Production Possibilities of Forage Crops.

Leaders: F. S. Prince, P. T. Blood, and L. J. Higgins.

During the season seed production possibilities of timothy, red clover, and Ladino clover have been investigated. In addition to the methods of handling and yield possibilities, we are interested in multiplying certain new clover and timothy strains that have developed in our breeding program (Purnell No. 93). This year two strains of timothy, four of red clover, and one of Ladino were threshed.

Timothy was harvested with an AC 40-inch combine in the field.

Red clover was cut with a mower and windrower attachment, then allowed to lay on the ground until curing was fairly complete. It was then threshed with the AC 40-inch combine equipped with a pickup attachment.

Ladino was cut with a windrower and dried indoors. This method of drying did not prove satisfactory as the quantity harvested was too large to cure satisfactorily in the space at our disposal. Unused greenhouse benches proved to be the best place for indoor drying and the germination of the seed produced was better than where the drying was done in a house in which drying was slower. After drying, the Ladino foliage was run

through a hammermill, then cleaned with an old clipper fanning mill. Cleaning the Ladino seed has been finally completed by using the rotary "scour kleen" sieve of the combine.

Yield data are not yet complete since not all of the seed has been recleaned. Preliminary estimates indicate that the acre yield for the three crops is about as follows: timothy 140 pounds; red clover 100 pounds; and Ladino clover 50 pounds. These figures are stated subject to correction after seed processing is completed.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Belle Ellen Pasture Experiment.

Leaders: C. B. Bender and Claude Eby.

The Belle Ellen pasture area, comprising 45 acres divided into 11 pastures under rotation management, carried 48 head of milking Holstein cows for 77.5 days and 47 head of milking Guernsey cows for 153 days. After deducting for grain and roughage fed other than pasture, the pastures yielded 1674 pounds of total digestible nutrients per acre, and produced 2768 pounds of 4 percent fat-corrected milk per acre. The Holstein herd obtained 52.6 percent of their nutrients from pasture and the Guernsey herd 39.3 percent.

Title: Fertility Levels on Dairy Farms.

Leaders: C. B. Bender, Firman E. Bear and Claude Eby.

A complete description and method of procedure of this project are contained in the 1941 Annual Report, page 83. The pastures furnished 153 days grazing for the milking herd.

The average dry-matter yield of the 20 bluegrass-white clover plots was 3346 pounds and the 20 Ladino clover-grass plots averaged 5702 pounds of dry matter. The Ladino clover-potash plots yielded the following:

1. No potash - 1979 pounds of dry matter.
2. 50 pounds K_2O - 6129 pounds of dry matter.
3. 100 pounds K_2O - 8569 pounds of dry matter.
4. 200 pounds K_2O - 8486 pounds of dry matter.

All the plots received 250 pounds of 20 percent superphosphate annually since 1941. This pasture was seeded to Ladino clover in 1937, and has not received any seed except natural seeding since that time. In studying the herbage analysis of the

plots we find that plots 2 and 3 are nearly identical in composition, yet plot 3 had an increase of nearly 2500 pounds of dry matter over plot 2. The extra 50 pounds of potash that plot 3 received over plot 2 caused a more vigorous growth of both the grasses and the Ladino. In plot 4 with a 200-pound application of K_2O , the Ladino was extremely vigorous, depressing the grass population, but this amount of potash did not produce any more total herbage as indicated in the above table. Plant counts of these plots are reported as follows in percentages:

<u>Plot</u>	<u>Coverage</u>	<u>Grass</u>	<u>Clover</u>	<u>Weeds</u>
1	95.0	41.7	31.3	22.0
2	98.0	45.2	44.8	8.0
3	98.0	43.0	47.5	7.5
4	95.0	27.0	62.6	5.4

A complete summary of this experiment (1941-45) will be presented in the next annual report.

Title: Pasture Fertilization in Relation to Carrying Capacity (Wyker Farm).

Leaders: C. B. Bender and Claude Eby.

The Wyker Farm, a pasture area comprising 41.5 acres grazed by growing dairy heifers, produced an average gain in live weight of 213 pounds, at a cost of .055 cents per pound. The area, rotationally grazed, yielded an average of 2039 pounds of total digestible nutrients per acre. The gain in live weight per animal was 171 pounds for a grazing season of 153.5 days.

Title: New Pasture Species.

Leaders: C. B. Bender and Claude Eby.

A 4-acre pasture on Belle Ellen farm seeded in 1943 to Ladino clover and Brage orchard grass contained 28 percent orchard grass and 45 percent Ladino clover. This pasture yielded 6831 pounds of dry matter per acre.

No other data for new pasture species are available for 1945 because of labor shortage for making plant counts and taking yield samples.

Title: Beef Cattle Experiment with Orchard Grass.

Leaders: Gilbert H. Ahlgren and George Van DerNoot.

This project was inactive in 1945 due to the unavailability of the needed cattle for pasturing.

Title: Pasture Renovation Studies.

Leaders: H. R. Cox and Gilbert H. Ahlgren.

Four new tests were initiated in the spring of 1945, three in Somerset County, and one in Warren County. Each test consisted of an entire pasture field. Methods followed were variable, being adjusted to the requirements of each field and desires and convenience of the farmer. In all cases the sods were fairly open, consisting of orchard grass, timothy or thin stands of bluegrass. Suitable applications of lime and complete fertilizer were made in March. In two tests the fields were then disk harrowed, in one test there was no tillage, and in one test part of the field was disked and the remainder not disked. In all tests a seed mixture containing Ladino clover was then sown; in one case orchard grass seed was added to the mixture. On account of the unusually early season all operations were completed in late March or early April. During the period of seedling establishment the weather of 1945 was unusually favorable, so that good stands of the clovers were secured in all tests. By fall it was apparent that the clover population had been greatly increased, with a high proportion of Ladino in all sods. There was considerable evidence that the disking was not markedly helpful this year in insuring stands of clover and orchard grass from these seedings.

Three additional tests were sown in the fall of 1945, one in Sussex and two in Warren County. Two tests include Ladino and alfalfa overall with strips of orchard grass, brome grass, timothy and reed canary grass. One test was seeded to the grasses only because of the late time of planting.

Seedbeds were prepared by disking from several weeks to a month in advance. Lime and fertilizer were added as needed and a top-dressing of manure is to be applied on two of these tests.

Fairly good stands have been obtained on all pastures.

Title: Methods of Seeding Large Grass Seeds.

Leader: Gilbert H. Ahlgren.

The brome grass seeding test described in the 1944 Annual Report, page 81, has been observed on several occasions during the past season. Results have been difficult to judge because of a fairly heavy stand of orchard grass coming into the brome grass and alfalfa mixture. The orchard grass was apparently native in the field and came back vigorously in the spring after seeding down.

There is a stand of about one-fourth brome grass, one-third orchard grass, and the rest alfalfa in this field. The brome grass seems to be a little stronger where seeded by mixing with 250 pounds of fertilizer per acre as compared to seeding by planting with one bushel of oats.

An excellent stand of brome grass and Ladino clover was secured at the College Farm by mixing 12 pounds of the brome seed with 250 pounds of fertilizer, and this amount applied per acre in late August. The Ladino was seeded simultaneously through the grass seed hopper. A 4-acre field of this mixture is now growing on the Farm property. The mixture is about 50 percent Ladino and 50 percent brome grass.

A 4-acre plot of tall oat grass and Ladino was also seeded in late August. The tall oat grass seed mixed with fertilizer at the rate of 15 pounds of seed to 250 pounds of fertilizer would not go through the fertilizer attachment on the grain drill. It was necessary to use a lime spreader finally and some difficulty in getting uniform seeding was experienced. Seeding in both an East-West and North-South direction largely solved this problem. The Ladino seed was sown separately through the grass seed attachment on the grain drill. A stand of about 40 percent Ladino and 60 percent tall oat was noted late in the fall.

Title: Korean Lespedeza with Continuous Small Grain.

Leader: Herbert R. Cox.

Growing self-seeded crops of Korean lespedeza with oats seeded every spring without plowing has been under observation in New Jersey for three years. Eight tests were carried on in 1945, two of which had been started in 1943, three in 1944. This plan offers the advantage of producing two crops in one season, a crop of oats for grain, hay or silage and a considerable amount of summer and fall pasturage from the

lespedeza, at comparatively low operating costs. Furthermore, the preparation of a seedbed for oats by the use of the disk harrow or tractor cultivator offers some advantages over plowing.

Our preliminary conclusion at this date is that if this system has a place in New Jersey it would be on land which has medium to strong acidity and a rather low fertility level. On the better soils where alfalfa and Ladino clover can be satisfactorily grown there would seem to be little place for lespedeza. Unfortunately, some of the fields selected for these tests were too good for lespedeza, with the result that weeds made a rank growth, and the clovers even made a fair volunteer stand in some of them. On several fields the soils were so acid and poor that the lespedeza did not have this competition, and here the crop made a remarkably good showing. The localities where the system might be best adapted are on the rather poor shaly soils of Somerset and Hunterdon Counties. It was found that in this territory the 19604 strain of Korean is a more dependable self-seeder than the standard Korean.

Title: Effect of Fertilizer Treatment and Stage of Harvest on Yield and Persistence of Timothy.

Leaders: H. C. Knoblauch and G. H. Ahlgren.

This project completed in 1944 and is now being prepared for publication.

Title: Comparative Yields of 13 Grasses Under Two Cutting Systems.

Leader: Gilbert H. Ahlgren.

This test was described in the 1944 Annual Report, page 83. The plots cut to simulate close grazing were clipped every time the herbage got up to a 3- or 4-inch height. Plots representing the deferred grazing system were harvested when the grass was 4 to 6 inches tall.

Considerable increase in percentage clover content occurred this past year with the clover estimated at 50 to 75 percent of the herbage. The increase was slightly greater on the more regularly clipped plots than on those where deferred cutting was practiced. More clover this year was attributed to the moist, cool weather throughout most of the growing season.

Average yields from all plots were over 4-1/2 tons of dry matter per acre. The low yield was made by meadow foxtail and clover in the deferred cutting system with a little over 2-1/2 tons of dry matter per acre. The highest yield was made by the plot originally in ryegrass and clover but now almost 100 percent clover. The yield was almost six tons of dry matter per acre made under the system simulating close grazing.

Title: Comparison of Orchard Grass and Bromegrass Strains for Pasture Purposes.

Leaders: Gilbert H. Ahlgren, Carl B. Bender, and Carleton S. Garrison.

Tests of Brage and S-26 orchard grass compared to commercial seed and of Achenbach, 2683-1, and Northern bromegrass are continuing as reported last year (1944 Annual Report, page 84). These tests are both under pasture conditions at New Brunswick and in Warren County. Observations only have been made this past year and are similar to those reported last year.

Eight demonstration plantings of bromegrass have been made in six counties. Lincoln or Achenbach smooth bromegrass is being compared with northern type bromegrass, timothy, and orchard grass for pasture on productive, well-drained soils. These seedings were made in August and October. All fall seedings were sown with wheat as a companion crop. Yield data will be obtained by placing cages on the various plots in each of the pastures.

Observations made on pasture renovation plots seeded in North Jersey five years ago showed that orchard grass has been the most successful in surviving on the steep hillsides. All other legumes and grasses seeded at the same time have disappeared. The pasture has not been managed carefully.

A comparison between strains of orchard grass and smooth bromegrass shows that the former has been more successful on a productive pasture field with a 15 percent slope. The orchard grass has provided a good stand. There is little difference between S-26 or Brage strains of orchard grass. The stands of smooth bromegrass are not as thick as would be desired and therefore the yield from these plots has been lower. The Achenbach strain has given double the production of the northern type of bromegrass. This pasture has an overall seeding of alfalfa, red clover, and Ladino clover.

Title: Improved Grass Species and Strains.

Leader: Gilbert H. Ahlgren.

Dry-matter production from 21 grass strains, each replicated three times, was secured. The first cutting was taken for hay and two aftermath harvests were made. The aftermath-yield data have not been analyzed as yet and therefore are not reported.

Commercial timothy and Milton yielded about the same total dry matter. No advantage of one over the other appeared evident. The Brage and S-26 orchard grass strains were somewhat better than the commercial material.

The biggest difference was apparent in the bromegrass strains again this year. The Achenbach and 2683-1 yielded 3630 and 3510 pounds of dry matter, respectively, compared to 1980 pounds only by the northern type.

Redtop produced over 4300 pounds of dry matter per acre, outyielding all the other grasses. Kentucky bluegrass produced only 1200 but it was very difficult to get a clean cut from the bluegrass plots and these are probably underrated by several hundred pounds.

Reed canary grass, orchard grass, bromegrass, timothy, and redtop gave the largest hay yields in these tests. The season was moist and cool and very favorable for good hay yields.

Title: Grasses and Legumes for Poultry Ranges.

Leaders: Gilbert H. Ahlgren and C. S. Platt.

Comparative tests of bluegrass ranges with Ladino clover and Ladino clover and ryegrass ranges were made this past season. Each yard or range was 50 by 50 feet in area and 50 pullets were grazed on each range.

A few seasons' conclusions follow:

1. Actual saving in total feed consumption by use of grass range in comparison with total confinement was insignificant.
2. Grass range saved in mash consumption, however, the amount approximating 30 percent. (Range-reared birds consumed more grain than birds in confinement, even though all groups had free choice of grain and mash.)

3. Neither the grass nor Ladino clover affected total feed consumption except that pullets on ryegrass pasture, poor as it was, consumed slightly less feed than those having access to other grasses.
4. Mature body weight of pullets was not significantly affected by rearing conditions as to type of grass or none at all as in confinement.
5. Egg production, while the pullets were still on growing rations or up to September 21, was greatest with pullets reared in confinement on a complete mash, but satisfactory in all lots except birds in confinement on an incomplete mash.
6. After transfer to a ration designed for egg production, the pullets reared on Ladino clover or on bluegrass with a complete mash gave the best results, indicating some relationship between the nutrition during the latter part of the growing period and egg production after maturity. A comparison of these two groups indicated a saving of 20¢ a bird in the cost of feeding during the rearing period after allowing credit for eggs produced on range. This saving is as near as can be measured in the project of this year on the relative values of Ladino clover and a range of poorer quality grass. With 400 birds per acre, the value of the clover at 20¢ a bird would be \$80.00. The saving of bluegrass range over strict confinement was 13.7¢ per bird, or \$54.80 per acre at 400 birds per acre.

Title: All Roughage and Pasture Program.

Leaders: Gilbert H. Ahlgren and C. B. Bender.

This study is concerned with making full use of hay, silage, and pasture in the dairy feeding program. As good pastures as possible will be developed and these will be supplemented with hay and silage as needed but no grain will be fed to milking cows on test during the entire pasture season.

Two pasture plots, each four acres in size, have been seeded to Ladino clover and bromegrass and to tall oat grass and Ladino. A good stand of each exists and a high proportion of both grass and clover is present on each plot.

Two more pasture plots of the same size will be prepared and seeded down in August 1946. One plot will be left in Kentucky bluegrass-white clover. A portion of the dairy herd at New Brunswick will be assigned to the study.

CORNELL UNIVERSITY (NEW YORK) AGRICULTURAL
EXPERIMENT STATION

Title: The Value of Birdsfoot Trefoil as a Pasture
Legume in New York.

Leader: H. A. MacDonald.

The work of this project was continued in 1945, although some of the older established trial plantings were discontinued to give way to other investigations. The results of the past year support those previously reported. When the method of management was adapted to the strain of birdsfoot trefoil, this legume has outyielded most other pasture legumes used. It has increased the yield of most mixtures to which it has been added by a significant margin.

In trials where different strains of birdsfoot trefoil were subjected to varying degrees of simulated grazing intensity, the larger-growing strains were most productive under the least severe clipping. Under close clipping many of these strains were severely injured and are being replaced by volunteer white clover. The smaller and less upright strains have persisted under close clipping although there has been a severe encroachment of white clover into these treatments. These plots, now a mixture of birdsfoot trefoil, white clover and Kentucky bluegrass, have produced higher pasture yields than the plots of white clover and bluegrass, included in the series.

A series of birdsfoot trefoil-grass mixtures is now under study. The primary object of this study is to evaluate the compatibility of birdsfoot trefoil with different grasses from the point of view of the quantity and quality of grazeable aftermath production.

The selection of superior strains of birdsfoot trefoil, for use in pasture seedings, is being continued. Some of these will be tested and others increased for further trial during 1946.

Title: The Influence of Fertilizer Treatment on the
Chemical and Botanical Composition of Pasture
Herbage and upon the Yield and Seasonal
Distribution of Growth.

Leader: D. B. Johnstone-Wallace.

Plots were established in 1934 and 1940 on an old grass turf which had received no fertilizer treatment for at least 25 years previously. The effect of fertilizer

treatment on the yield, seasonal distribution of growth, botanical composition and chemical composition is being studied on the existing sward and on plots plowed and seeded with the Cornell Pasture Mixture. Soil samples are tested periodically by the rapid microchemical soil tests described by Peech and English in Soil Science, Volume 57, No. 3, 1944.

Determinations have been made of the earthworm content of plots treated in various ways and measurements have been made of the carbon dioxide content of the soil and of the air above the soil.

Title: The Influence of Methods of Grazing Management upon the Yield, Chemical Composition, and Botanical Composition of Pasture Herbage.

Leader: D. B. Johnstone-Wallace.

A field having a uniform stand of wild white clover and Kentucky bluegrass was divided into small plots, each receiving a certain type of treatment in regard to time and method of harvesting. The treatments include four general types as follows: (1) clipping to approximately one-half inch of the ground surface when the herbage reaches heights of 2, 4, 6, and 8 inches; (2) clipping to 1/2, 2, and 4 inches from the ground surface; (3) clipping at intervals of 1, 2, 3, 4, 6, 8, 12, and 24 weeks; and (4) variations in dates clipping begins and ends, and combinations of hay, silage, and pasture production.

The results in 1945 were similar to those previously reported. The most desirable type of sward and the highest yields of dry matter and protein are produced by plots clipped frequently and closely to simulate periodical close grazing by stock. The percentage of clover present increases when the frequency of clipping is increased. Plots clipped to one-half inch from the ground surface produce a considerably higher yield than plots clipped less closely and contain a higher percentage of clover.

A new series was established in 1945 in which methods of harvesting will be modified in directions indicated by the results of the technic experiments.

Title: A Study of Plant Associations for Pasture Purposes.

Leader: D. B. Johnstone-Wallace.

Species and varieties of grasses and legumes are grown alone and in association on field plots. Clippings are made with special power lawn mower at intervals during the growing season to simulate periodical close grazing. The herbage so obtained is weighed before and after drying. Botanical analyses are made, and samples are subjected to chemical analysis to determine the nitrogen, phosphorus and calcium present. Soil samples are subjected to rapid microchemical tests.

The 1941 silage-pasture mixture series was plowed in the fall of 1944 and a new series was established in 1945.

The 1941 technic series was continued in 1945. This consists of five grasses--Kentucky bluegrass, Olds creeping red fescue, E. F. 79 perennial ryegrass, Aberystwyth S. 143 pasture orchard grass, and commercial orchard grass, grown in turn with Kent wild white clover, Ladino white clover, and New York wild narrow leaved birdsfoot trefoil.

Plots of the same five grasses grown in association with Kent wild white clover are subjected to three different technics of harvesting. One series has all clippings removed, another has 60 percent of the clippings returned after each clipping, and the third series has manure and urine, equivalent in amount to that which it is estimated grazing cattle would produce from the herbage, returned to each plot after each clipping.

During a period of three years, Old creeping red fescue has produced the highest average yield, but it is closely followed by Kentucky bluegrass. During the same period Ladino white clover has given the highest yield, but it is closely followed by birdsfoot trefoil.

The highest yield of herbage has been produced by Kent wild white clover and grass with 60 percent of the clippings returned. The return of clippings has increased the yield by 50 percent, whereas the return of manure has increased it by 12 percent.

Changes in the appearance and botanical composition of the plots have been recorded, also the results of rapid microchemical soil tests.

The 1938 pasture-mixture series was plowed up in the fall of 1944 and records and photographs have been obtained which show the remarkable influence of different grasses on soil structure.

The 1939 and 1940 series were continued in 1945, and a new series was established. The special pasture and silage-pasture mixtures, developed as a result of previous trials, increased production by more than 30 percent over the control plots of Kentucky bluegrass and wild white clover, and improved distribution of growth in 1945.

Selections have been made from surviving plants of E. F. 79, Svalöf Victorial, and Jaedrsk perennial ryegrass, N. Y. wild creeping red fescue, Aberystwyth S. 143 orchard grass, Aberystwyth S. 48 timothy, English wild meadow foxtail, and a procumbent alfalfa from the 1938, 1939, and 1940 series as foundation material in the plant breeding program.

Title: White Grub Investigations.

Leaders: H. H. Schwardt and R. F. Pendleton.

Seasonal history studies of the past two years show that the relative importance of the three broods of Phyllophaga occurring in New York is changing rapidly. The "C" brood still predominates and has become much heavier in Niagara, Orleans, Monroe, and Wayne Counties. A "B" brood infestation bordering the Adirondack area on the west and south is apparently on the increase. In 1945 a small "A" brood infestation was found in southern Wyoming County.

The usually rare white grub fungus, Cordyceps ravenelii Berkley and Curtis, has recently been found in abundance in southern St. Lawrence County. Some progress has been made in culturing this organism but the sporulating stage has not as yet been obtained except in the field. Attempts to establish new infestations by transplanting sporulating specimens have not been successful but further attempts will be made.

Title: European Chafer Investigations.

Leaders: H. H. Schwardt, C. Logothetis, and W. H. Whitcomb.

Extensive field tests show that the European chafer adult is easily killed with DDT sprays or dusts in concentrations as low as 3 percent. In laboratory tests a 94 percent mortality of first stage larvae was obtained with 30 pounds per acre of

DDT. Nearly equal effectiveness was obtained with dosages as low as 10 pounds per acre but more time was required for the kill. Thirty pounds of DDT was more effective than 1,000 pounds of lead arsenate. In field tests larvae were effectively controlled with dosages from 10 to 30 pounds per acre only when the material was plowed under to a depth of about six inches. Surface applications were much less effective.

Ethylene dibromide and DD mixture are effective against third stage European chafer larvae when used as soil fumigants. Ninety to 100 percent control was obtained with either material at a dosage of 2 cc. per square yard. Results were approximately the same whether the material was injected in dilute form or applied to the surface as an emulsion.

Title: Poultry Pastures.

Leaders: G. F. Heuser and L. C. Norris, Department of Poultry Husbandry, cooperating with D. E. Johnstone-Wallace and J. K. Wilson, Department of Agronomy.

On June 28, 1945, three lots of Single Comb White Leghorn pullets, two months of age, were placed on pasture and grown for four months. The pasture consisted primarily of Ladino clover. The range was kept mowed and remained in excellent condition during the entire period. All birds were reared on a good starting ration until they were two months old.

Lot one received a regular growing mash and grain (wheat), hopper fed, and it was available at all times. Lot two received yellow corn only, cracked and ground--fed separately free choice. A mineral mixture was added to the ground corn to make the mineral content comparable to lot one. Lot three was fed wheat only, whole and ground, with mineral mixture added to the ground grain and fed free choice.

The differences in average weights were relatively small, but the corn-fed group was consistently lower than the control or wheat lots. Feed consumption was slightly lower in the corn fed lot, however.

Lot two (corn) reached sexual maturity more slowly than lot one (control) and lot three (wheat). At six months of age the percentage of birds in production was 16, 2.7, and 13.6 for lots one, two and three, respectively. This was in

agreement with the 1944 results where it was found that birds fed wheat only and reared on a good Ladino clover range, matured at approximately the same time as control lots fed in the customary way.

Title: Breeding and Cytogenetic Investigations with the Forage Plants of New York.

Leaders: S. S. Atwood, R. G. Wiggans, and L. F. Randolph.

The red clover plots sown in 1944 were harvested for aftermath yield on August 22 and 23, 1945. The data are not yet summarized, but all notes on the crop indicated that large differences between strains were obtained. It is planned to leave the plots at least through another year in order to make individual plant selections.

Good growth was obtained in the space-planted nurseries started in 1944. Notes were taken throughout the growing season, and marked differences were obtained in most characters observed. Selections were made mainly on the basis of time of maturity, disease resistance, vigor of first growth, and vigor of aftermath. In an attempt to obtain selfed seed, bags were placed on over 1,000 plants of brome grass, 500 of timothy, 100 of tall oat grass, and 100 of Ladino clover. Part of this material has been threshed, and it is evident that the plants range from completely self-sterile to completely self-fertile. Inbred lines will be started from the better self-fertile plants, and a polycross test will be made of the better self-sterile plants.

Further selections from the 1944 brome grass nursery are being tested at the Nutrition Laboratory for aftermath growth at controlled high temperature. The experiment now under way consists of three main parts: (1) evaluation of 38 clones chosen because of their outstanding recovery growth in the field during August, (2) repeat study of four "good" clones and four "poor" clones from the 1944-45 experiment, together with 12 clones selected in 1945 as representing the range of types in amount of recovery growth, and (3) a study of the effect of number of cuttings per pot on yield per tiller and yield per pot. Summaries have been completed of most of the results from the 1944-45 experiment, and these data are now being prepared for publication. These preliminary results indicate that the method may be very useful in selecting plants for ability to yield good aftermath at high temperature. Field plantings were made in 1945 for harvesting in 1946 in order to compare field behavior with the growth in the controlled chambers.

The 1945 Uniform Observation Alfalfa Nursery, consisting of 75 new single crosses, polycrosses, and other experimental lots, was sown in four replicated 1/2-rod rows on May 26, 1945. The stand is uneven due mostly to competition from weeds, but it may be adequate for preliminary notes if not for yield. The space-planted nursery of alfalfa was enlarged to include several selfed and crossed progenies, which had been produced in the greenhouse, together with cuttings of several selected clones. Among these clones were those from Nebraska as well as some of the better plants from the 1944 nursery. Seed of Doctor Myers' composite was sown in isolated plots for seed increase both at Lincoln, Nebraska, and at Ithaca, New York. Any further work on this material, formerly in a separate project, will now be included in this project.

A planting was made in May of the Red Clover Uniform Disease Nursery. Notes taken by Doctor Tyler, Department of Plant Pathology, show highly significant differences between strains for several diseases. No growth was removed from the plots in order to encourage natural epiphytotics, and parts of all plots were inoculated with Sclerotinia late in the summer.

The greenhouse study of male sterility in white clover was continued but due to the poor flowering of most plants, only a few crosses were obtained; those involving male-sterile plants are being grown for further testing in 1946.

In the fall of 1944, 78 selected cuttings were isolated from each of the following grass strains: Brage orchard, S.143 orchard, S.48 timothy, Svalöf Victoria perennial ryegrass, Danish E. F. 79 perennial ryegrass, Norwegian Jaedrsk perennial ryegrass, New York creeping red fescue, and English meadow foxtail. All of these had been grown in Agronomy Department plots that had been close clipped with a lawn mower for seven years. In the spring of 1945 the best 50 plants from each strain were divided into 10 to 15 cuttings each, and these were planted in polycross blocks for tests of their combining ability. The preliminary notes taken during the summer of 1945 showed marked differences between plants in such characters as vigor, leafiness, and disease resistance; these observations will be added to those in 1946 as a basis for eliminating certain plants.

Seed was harvested in 1945 from the isolation plots of 1777 and 4059 timothy. Some of the seed has been distributed to farmers and seed growers for increase. The new work along this line will be included in this project rather than in a separate project as previously reported.

The plots of zigzag clover were weeded once in 1945, but no yields were taken.

In a further test of the fertility of 4n red clover, selected clones were grown in isolation; this material has not yet been threshed, but it is evident that the seed set is low.

Title: Strain Testing and Breeding of Forage Plants for New York State and Vicinity, with Special Emphasis on Problems of Production During Periods of Mid-summer Drought.

Leaders: S. S. Atwood and H. A. MacDonald.

An effort was made during the winter of 1944-45 to collect seed of all improved strains and distinct ecotypes of the grass and legume species which appear to have greatest usefulness in providing good aftermath during the normally hot, dry periods of midsummer. Most of these varieties have been included in preliminary tests elsewhere, and on this basis 113 varieties were selected as follows:

Alfalfa	-	25
Bromegrass	-	30
Orchard grass	-	22
Timothy	-	16
Meadow fescue	-	8
Reed canary grass	-	6
Tall oat grass	-	6

The plots were sown in August 1945 on a field that had been fallowed throughout the summer. Each variety was included in four replicated plots seeded alone and four replications with an associated species. The plots were 6 by 24 feet, so that including the check plots the total of 1112 covered approximately five acres. A good stand was obtained, but the growth was so retarded with cold rainy weather that it is questionable how well the plots will survive the winter. It is planned to harvest these plots for early hay and aftermath with several cuttings per season.

In April 1945, 15 of the same bromegrass varieties were sown in plots on the Agronomy field at Churchville in an experimental design similar to the one outlined above. Plans have been made for expanding this type of testing in 1946.

Certain other phases of the breeding work, particularly with spaced plants and with the testing for aftermath growth at controlled high temperature, have been supported in part by this project; those results are reported in connection with the other breeding project.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: The Adaptation of Species of Grasses and Legumes to the Varying Soil and Climatic Conditions in Pennsylvania.

Leaders: J. K. Thornton and H. W. Higbee.

Seedings have been established and yields obtained for the first season on three of the areas selected for adaptation of forage species. Fair to good stands of grasses and legumes were obtained on all sites. However, late cutting and competition by the grasses have retarded both Ladino clover and alfalfa in the first season. Yield records will not be reported until later. Each of the grasses being tested has been found to be generally well adapted.

Timothy was the most productive grass on the well-drained plots in Crawford County. Timothy and Ladino clover were as productive as the timothy-alsike-red clover mixture, which is common to the glaciated soils of that part of Pennsylvania.

On the thin shale soils in Huntingdon County, tall oat grass was especially well adapted. This grass grows with but little moisture and makes a good combination with alfalfa.

Title: The Importance of Soil Amendments in the Establishment, Maintenance, and Productivity of Grasses and Legumes.

Leaders: H. W. Higbee and J. K. Thornton.

Yield records were obtained from alfalfa, Ladino clover, orchard grass-Ladino, and brome-grass-alfalfa, each of which were grown on 22 different fertility treatments.

On the glaciated area the no-treatment plots remained bare and unproductive, while on some of the higher treatments over three tons of air-dry forage were produced per acre. A farmer could afford to apply a number of the treatments which were found to produce yields of two tons of forage per acre. Ladino clover and birdsfoot trefoil made excellent growth on many of the treatments, and the same was true of orchard grass and brome-grass.

The fertility plots on the shale soils of Huntingdon County were not harvested for yields, as the legumes had not become well established in 1944. The legumes were

reseeded in the spring of 1945. Except on the no-treatment plots tall oat grass appeared to respond to treatment on this soil. Winter and spring feeding by the deer injured the young alfalfa plants more than the birdsfoot trefoil plants.

Title: Silage Investigations.

Leaders: S. I. Bechdel, P. S. Williams, and S. R. Skaggs.

During the early months of 1945, three feeding tests were conducted to compare the feeding value of grass silages which had been stored during the summer of 1944.

1. At Farm 12, the college experimental dairy farm, Ladino clover silage was fed in comparison with good quality corn silage. The Ladino clover silage was made by the addition of 200 pounds of oats feed per ton of the green chopped material as it was blown into the silo. This produced an exceptionally bright and palatable grass silage.

A rather poor quality mixed clover and timothy hay was fed along with a good dairy grain ration.

Results. This feeding trial indicates that the grass silage was equal but not superior in feeding value to good quality corn silage. Milk production was almost the same for the two groups of animals, but those on corn silage made a greater gain in body weight during the feeding period than did the group on legume silage (Table No. 17).

2. At the college dairy barn a test was run to compare the feeding value of silage made from heavily nitrogen-fertilized orchard grass with that made from unfertilized orchard grass. Half of the orchard grass field was top-dressed in the spring with ammonium nitrate at the rate of 75 pounds of nitrogen per acre. The remainder of the field was not fertilized.

The grasses were stored in separate silos. As a preservative, 200 pounds of oats feed per ton of green grass was mixed and blown into the silo with the chopped grass.

A good dairy grain ration and chopped alfalfa hay were fed along with the grass silage.

Results. During the 9-week feeding period the group of cows fed the fertilized grass silage produced 5 percent more milk and gained 10 percent more in body weight than did the group getting the silage made from unfertilized grass. At the end

Table 17. Comparative analysis of the silages.

	Percent	Percent on oven-dry basis				
		Ash	Ether	Crude fiber	Nitrogen-free extract	
	total					
	moisture					
Clover	71.92	7.38	4.82	14.69	32.31	38.66
Corn	68.04	4.71	2.46	7.38	23.73	58.89

Table 18. Comparative analysis of silages.

	Percent	Percent on oven-dry basis				
		Ash	Ether	Crude fiber	Nitrogen-free extract	
	total					
	moisture					
No nitrogen	74.24	7.61	4.91	11.19	34.56	39.72
Nitrogen	69.12	8.54	3.90	11.50	37.23	36.77

Table 19. Comparative analysis of silages.

	Percent	Percent on oven-dry basis				
		Ash	Ether	Crude fiber	Nitrogen-free extract	
	total					
	moisture					
No nitrogen	44.55	4.74	2.69	7.56	35.34	48.92
Nitrogen	60.41	4.64	2.89	9.63	36.25	45.91

of the feeding period, the group getting the unfertilized grass silage was 12 percent below the other group in daily milk production.

While the increase in the yield of grass and the comparative analyses of the two silages do not appear to warrant this heavy application of nitrogen, the apparent difference in feeding value in favor of the nitrogen-fertilized grass probably would make the investment well worthwhile (Table No. 18).

3. At the Montrose experiment farm, a feeding test was run to compare the feeding value of heavily nitrogen-fertilized timothy silage with that made from unfertilized timothy.

Half of the field was top-dressed with ammonium nitrate at the rate of 75 pounds of nitrogen per acre while the other half received no fertilizer. The timothy was cut for silage before full bloom and preserved by the addition of 200 pounds of hominy feed per ton of green grass.

The resulting silages were fed with a good grain ration and medium quality mixed hay to two evenly balanced groups of milking cows.

Results. Although the group getting the nitrogen-fertilized grass silage consumed less silage than the other group, they produced about five percent more milk during the test period. At the end of the feeding period, they were about 8 percent higher in daily milk production than the group receiving unfertilized grass silage.

Again we find that the yield of grass as a result of this heavy nitrogen fertilization would not warrant the investment involved. However, when we consider the increased feeding value of the silage or hay made from the fertilized grass it might prove to be a very good investment (Table 19).

RHODE ISLAND AGRICULTURE EXPERIMENT STATION

Title: Effect of Sources of Lime on Composition and Yield of Grass-Legume Hay.

Leaders: T. E. Odland and Avery E. Rich.

A series of plots was limed for a period of years with either calcium or magnesium lime in both the hydrate and the lime-stone forms. One plot was left unlimed for a check. None

of the plots has received any lime for the past 20 years. The average composition and yields of hay for the past six years from the various plots are shown in Table No. 20.

Table 20. Residual effect of different forms of lime on yields of forage.

Source of lime	: pH	: pH	Percent		:Tons per
	: 1928	: 1945	:Legumes	:Grasses	: acre
Calcium hydroxide	: 7.80	: 6.00	: 56	: 44	: 3.20
Calcium carbonate	: 7.46	: 6.00	: 58	: 42	: 3.26
Magnesium hydroxide	: 7.59	: 6.10	: 66	: 34	: 3.24
Magnesium carbonate	: 7.28	: 5.90	: 61	: 39	: 3.14
No lime	: 4.57	: 4.56	: 7	: 93	: 0.85
	:	:	:	:	:

These results show the lasting effect of the lime which was applied 20 years or more ago. Apparently the source of lime is unimportant for hay, but it is very important that lime be added in order to produce a satisfactory hay crop with a high percentage of legumes.

Title: Effect of Potash on Composition and Yield of Grass-Legume Hay.

Leader: Avery E. Rich.

A standard hay mixture of seven pounds of alfalfa, five pounds of red clover, three pounds of alsike clover, three pounds of timothy, and two pounds of redtop was seeded with oats on a series of plots in the spring of 1941.

In order to determine the fertilizer requirements of this crop over a period of years, varying amounts of nitrogen, phosphoric acid, and potash have been applied to the different plots. The standard application was 20 pounds of nitrogen, 80 pounds of phosphoric acid, and 100 pounds of potash per acre annually as a top-dressing. Reducing the nitrogen to 10 and 5 pounds, respectively, or reducing the phosphoric acid to 40 and 20 pounds, respectively, had no significant effect on either the yield or the percentage of legumes in the hay.

Reducing the potash from 100 to 50 pounds, however, reduced the percentage of legumes from 50 percent to 3 percent and reduced the yield from 3.08 tons to 1.63 tons per acre. A further reduction in potash to 25 pounds reduced the legumes to less than two percent and resulted in a yield of only 1.17 tons per acre.

Title: Alfalfa Nursery (In cooperation with Eastern Alfalfa Improvement Group).

Leader: T. E. Odland.

Forty-four different alfalfa seedlings were planted in duplicate 16-foot rows in order to determine which ones are best adapted to Rhode Island conditions. Outstanding differences were observed in regard to growth, leafiness, and resistance to diseases and insects. Future observations will also be made concerning yield and winter hardiness.

Title: Diseases Found in Forage Crops.

Leader: Harry L. Keil.

The following list of diseases found on forage crops in Rhode Island in 1945 does not include those previously reported:

<u>Host</u>	<u>Common name of disease</u>	<u>Name of pathogen</u>
Red clover	Ring spot	Stemphylium sarcinaeforme
Alfalfa	Leaf spot	Pseudopeziza medicaginis (heavy infestation)
Ladino clover	Rust	Uromyces Trifolii
Alsike clover	Rust	Uromyces spp.
Bentgrass	Leaf spot	Passalora graminis
Ladino clover	"Blight" of foliage	Alternaria sp. (probably saphrophytic)
Birdsfoot trefoil	"Blight"	Rhizoctonia solani (identi- fied by Roderick Sprague)
Alfalfa	"Ring spot"	Stemphylium botryosum

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Fertilizer Placement Studies for Legumes.

Leaders: A. R. Midgley and K. E. Varney

Very good stands of Lotus (Birdsfoot trefoil), alfalfa and Ladino clover were obtained from seeding 1-acre plots of each legume with brome grass. Somewhat better growth was obtained the seeding year from applying manure and fertilizer on top of the plowed land rather than plowing them under, but the differences were quite small on the three different soil types. Each acre received 10 loads of manure and to each

load 100 pounds of an 0-20-20 fertilizer and 5 pounds of borax were added. This treatment was planned to last 4 or 5 years.

The good stands of Lotus seem to be due to a better method of inoculation. When a clay suspension is mixed with the inoculum, the material sticks to the seed and does not separate. Lotus seed is small, hard, and very smooth with little possibility of the inoculum adhering to it. This is not such a serious matter with most of the other ordinary legumes because our soils naturally contain a larger number of these organisms.

Lotus cannot stand excessive competition during its early growth because it starts quite slowly. In these trials, a companion crop (oats) was used in order to get brome grass through the seeder, but the oats was seeded at a low rate of about one bushel per acre.

Title: Comparative Longevity and Yield Tests with 10 Grasses and 4 Legumes.

Leaders: A. R. Midgley and K. E. Varney.

On the very light soils practically all the legumes died after the second year. Alfalfa and Lotus grew much better than Ladino clover and they still show some promise on this light soil if given a higher degree of fertility. Tall oat and the different strains of brome and orchard grasses grew much better than timothy. Orchard and tall oat grasses were more drought resistant than the other grasses used.

All legumes and grasses did well on the heavy clay soil. After the first year, Lotus produced as much as alfalfa and more than the other legumes. Lotus does exceptionally well on this heavy clay land and will no doubt live longer than any other legume. At present it shows considerable promise as a perennial legume for the heavy Panton clay in Vermont.

Title: Comparative Value of Birdsfoot Trefoil and Ladino Clover.

Leaders: A. R. Midgley and K. E. Varney.

These two legumes have been seeded either with brome grass or timothy on three soil types. Table No. 21 gives the average yield of dry matter per acre over a 3-year period. During the first two years, Ladino clover yielded more than

Lotus but after this time considerable Ladino clover died, thus putting it at a disadvantage. The excellent stands of Lotus continued to get better and, for the 3-year average, it produced greater yields. Some volunteer Ladino clover has started to come back in the plots but since Lotus is usually a long-lived perennial, differences may be even greater in its favor next year.

Table 21. Comparative yields of Ladino and Lotus on different soil types.

Soil type	Average yield per acre	
	Ladino	Lotus
Panton clay	3,285	4,643
Addison clay	4,114	5,261
Woodbridge loam	4,860	5,800

Title: Cytogenetics and Breeding Investigations with Forage Legumes.

Leader: A. Gershoy.

Trifolium medium. An unfavorable season for increase in the local bumble bee population prevented the completion of diallel cross-pollination of 20 strains of zigzag clover begun in 1944. Flower heads of plants visited by queen bees in late May and by workers from August on set seeds freely, thus confirming data obtained in 1943 and 1944.

Progeny rows, each consisting of 25 or more individuals from the 1944 crosses, showed some genetic combinations to be decidedly superior over others. Study of offspring obtained from open-pollinations of a large number of strains indicates that, whereas any mother plant may produce one to several outstanding individuals, there is a marked difference in the frequency of occurrence of desirable progeny.

Seedings were made in association with timothy and smooth brome grass on heavy clay, gravelly loam and fine sand. Because clean cultivated land was not available, the seedings were made on turned sod land. Unfavorable weather conditions necessitated late plantings--in middle May on light soil and in late June on clay and loam. A heavy growth of annual weeds was removed by hand several times during the season. The competition of brome grass, seeded eight pounds to the acre, appeared to be too severe for the clover on all types of soils. A similar rate of seeding of timothy formed an

insufficient ground cover against drying. As indicated by a very slow growth and a reddening of leaves, the seedlings showed a lack of tolerance to the low lime and fertility level of the gravelly and especially the light, sandy soil. However, on these lighter soils the clover endured a severe drought lasting through July, August, and the first week of September, in spite of the late seeding. Yields in these beds will be taken in 1946 and 1947. Earlier seedings with additional grass associations will be made in 1946.

The problem of determining chromosome number in zigzag clover:

To facilitate a study of chromosome number in strains of zigzag clover, technics of fixations and pre-treatments of root tips have been investigated. From a variety of killing solutions including Bouin's, Flemming's, and Navashin's fluids, a modification of the last, suggested by Doctor S. S. Atwood, has been adopted as standard. The presence of a high number of chromosomes and their tendency to form crowded, overlapping configurations, however, have rendered heretofore the determination of an accurate count uncertain.

The cold shock treatment of Hill and Myers (Stain Technology, 1945), modified in that the germinated seedlings were kept at 37° to 38° F., is quite promising; mitotic figures are stopped at metaphase, the chromosome spiral is condensed, and the individual chromosomes appear fairly well spaced, lying in a flat plane.

Additional pre-treatments were tried as follows:

- a. Ten to 15 minutes' immersion in a 0.05 percent solution of magnesium sulphate at room temperature; the chromosomes appear shorter and moderately well spaced, but the staining intensity (in iodine-crystal violet) is lessened.
- b. Ten to 15 minutes' immersion in a 0.05 percent chlorbutanol solution; occasional metaphase plates can be counted but there are such general unfavorable reactions as distortion of plates, loosening of the metaphase spiral with subsequent curvature of chromosomes and loss in intensity of staining. Stronger solutions give decidedly poor preparations and, even after periods of recovery up to 72 hours, injurious effects are quite evident. It is of interest to note that the cold shock treatment following immersion at 0.05 percent concentration results in a separation of shortened chromosomes so that they lie scattered in the several planes of the metaphase plate; these are more or less difficult to count accurately. In such preparations the mitoses are stopped at metaphase.

c. Fifteen to 30 minutes' immersion at room temperature in a saturated aqueous solution of paradichlorobenzene (Myers, Stain Technology, 1945); a variety of effects has been observed such as distortion of mitotic figures, a greater or lesser scattering of chromosomes at metaphase throughout the spindle region and a foreshortening of chromosomes. The combination of cold shock treatment and use of paradichlorobenzene appears to prevent excessive scattering of chromosomes and also keeps mitotic figures at metaphase.

d. Immersion for shorter or longer periods in aqueous solution of colchicine ranging from 0.001 percent to 0.2 percent; higher concentrations even for short periods of treatment produce the expected cell injuries which are evident 96 hours later, although occasional mitotic figures lend themselves to uncertain counts because of scattering of chromosomes throughout the spindle region. Short period immersions in the weakest solutions produce scattered metaphases difficult to count because of necessity of focusing in several planes of optical section.

Further studies on combinations of above cited technics are in progress.

Lotus corniculatus. Additional progeny rows have been planted, derived from primary 1944 selections made in an imported, tall, coarse, broad-leaved strain 2n-24. Selections made in 1945 will be studied in 1946.

Beds have been seeded in association with smooth brome grass in Latin square plat replications with zigzag clover. As noted above the plantings were made late in heavy clay, gravelly loam, and light sand. This imported strain of Lotus is very aggressive, especially on the heavier soil, competing quite successfully with brome grass. In spite of the late seeding, it endured the prolonged summer drought and produced enough growth to warrant fall grazing.

Trifolium repens var. latum. Observations for two years on progeny rows of four strains of Ladino clover indicate that the mammoth types, i.e., the lush, thick stemmed, large-leaved plants, show a noticeable tendency to winterkill; at least there appeared to be complete destruction of the stolon between the primary seedling axis and the terminal nodes. These terminal nodes may or may not root firmly enough to produce derivative plants the succeeding year. The total growth the second year compares unfavorably with that of the seedling year. By contrast the off types and those intermediate in mammoth characteristics are more winter hardy and do not tend to expose large, bare areas following winterkilling.

To test longevity of desirable types of Ladino, terminal cuttings have been set out in well spaced rows and as spot plantings in old timothy swards.

A small series of colchicine-induced polyploids has been obtained. A large number of treated seedlings are being grown for study with the ultimate purpose of obtaining types at the tetraploid level for polycrosses and seed production.

As a check on the relation of frequency of occurrence of natural tetraploids to the efficiency of colchicine technic, a random sampling has been made in seedling roots of five seed sources. No tetraploids have been found in 65 individuals.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Studies.

Leaders: G. G. Pohlman and R. M. Smith.

Because of the favorable weather over most of the state, the yields of clipped plots were considerably higher than in 1944. Increases in yields for the best treatment amounted to 1705 pounds per acre at Gardensville, 810 pounds per acre at Lewisburg and 876 pounds per acre at Milton. The corresponding percentage increases are 212, 43, 138. All treated plots showed an increase over the checks, the greatest increase being from the application of lime to pH 6.0 and 800 pounds of 20 percent superphosphate every four years. These plots have received 1600 pounds of superphosphate during the six years of the experiment.

The average increases in yield for the 6-year period show almost a straight line relationship between percentage increase in yield and rate of phosphate applied, regardless of the size of individual application. The plots having higher rates of application likewise show greater percentage of desirable species. Legumes, particularly white clover, are more abundant one to two years after treatment with 400 pounds or more of superphosphate.

Title: Revegetation of Hill-land Pastures in West Virginia.

Leaders: R. M. Smith, D. R. Browning and G. G. Pohlman.

Yields from replicated caged areas were secured from 14 areas in 1945. In addition, yields from single or

duplicate cages were secured from several additional areas. Four new seedings were made, two of which were harvested for yield. Detailed estimates of ground cover and species composition were made on all areas.

The results thus far indicate the greatest return during the first and second years after seeding although increases over surface treatment were obtained during the third year on some of the areas. However, on most surface-treated areas natural succession has resulted in considerable increase in desirable species and in yield.

Flowed areas still show more bare space and greater erosion than surface-tilled areas.

Protein analysis from the clipped areas shows a much higher protein content on the reseeded areas than on those receiving only surface treatment of lime and fertilizer.

Most seedings were made on very poor pasture areas in an attempt to secure quicker response than could be obtained by surface applications of plant nutrients. In only two trials thus far has surface treatment equalled reseeding and in both of these legumes were fairly prevalent before treating.

Title: Reclaiming Eroded Soils.

Leaders: G. G. Pohlman and R. M. Smith.

Three seedings of various mixtures of legumes and grasses were made on eroded areas in eastern West Virginia in 1945. These are in addition to earlier seedings at Gardensville and Shinnston. No records of yields have been taken but careful records are being kept of survival and spread of the various species. It is expected that this project may give some information regarding kind of plants which are useful on these eroded areas for control of erosion and at the same time to enable the operator to secure some hay or pasture. Disking appears preferable to plowing in seedbed preparation on these areas. Several legumes, including sweet clover, birdsfoot trefoil, and Korean lespedeza, show considerable promise. Alfalfa, Ladino clover, and Lespedeza sericea also are growing fairly well on some areas. Orchard grass, tall oat grass and weeping love grass are the most promising grasses. The latter grass has an added advantage in that it is less palatable than the others and therefore no so likely to be overgrazed.

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